National Aeronautics and Space Administration

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# Expedition 19 and 20
# Full Partners


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# Mission Overview

## Expedition 19 and 20


***Attired in Russian Sokol launch and entry suits, cosmonaut Gennady Padalka (center), Expedition 19/20 commander; astronaut Michael Barratt (right), Expedition 19/20 flight engineer; and U.S. spaceflight participant Charles Simonyi join hands as they pose for a portrait in Star City, Russia. Photo credit: Gagarin Cosmonaut Training Center***

The crew of Expedition 19 will begin its journey to the International Space Station on March 26 from the Baikonur Cosmodrome in Kazakhstan, launching on a mission that will ultimately inaugurate the expansion of the station to six crew members. On board the Russian Soyuz TMA-14 spacecraft will be cosmonaut Gennady Padalka (Puh-DOLL'-kuh), astronaut Michael Barratt (BA'-rat) and U.S. spaceflight participant Charles Simonyi (Sih-MOAN'-ee).

Padalka, a 50-year-old Russian Air Force colonel, will command Expedition 19 and 20 as well as the Soyuz spacecraft for launch and landing. He is making his second voyage to the station after commanding Expedition 9 in 2004 and his third flight into space, having logged 387 days in orbit on his previous missions. Barratt, who will launch just days before his 50th birthday, will serve as a flight engineer on board the station and the Soyuz. He is making his first journey into space after extensive experience in the medical field, including serving as the medical operations lead for the International Space Station Program and as a NASA flight surgeon. Padalka and Barratt will spend about six months on the complex.

Simonyi, 60, will spend 10 days on the station under a commercial agreement with the Russian Federal Space Agency (Roscosmos), making his second flight to the station and becoming the first spaceflight participant to return to space. He will return to Earth on the Soyuz TMA-13 capsule on April 7 with the Expedition 18 crew, Commander E. Michael Fincke and Flight Engineer Yury Lonchakov (LAHN'-chuh-coff), who have been aboard the station since October 2008. The Soyuz will land in central Kazakhstan.

The Soyuz TMA-14 spacecraft that will carry the Expedition 19 crew and Simonyi will launch from the Baikonur Cosmodrome in Kazakhstan for a two-day flight and dock at the aft port of the Zvezda Service Module. They will join Flight Engineer Koichi Wakata (Ko-EE'-chee Wa-KAH'-tah), 45, of the Japan Aerospace Exploration Agency, who was launched to the station aboard space shuttle Discovery on its STS-119 mission. Wakata will transition from Expedition 18 to Expedition 19 once Padalka and Barratt take over station operations.

Once they arrive, Padalka and Barratt will conduct more than a week of handover activities with Fincke, Lonchakov and Wakata, familiarizing themselves with station systems and procedures. They also will receive proficiency training on the Canadarm2 robotic arm from the resident crew, engage in safety briefings and receive payload and scientific equipment training.

The change of command ceremony will mark the formal handoff of control of the station by Fincke and Lonchakov to Padalka, Barratt and Wakata, just days before the Expedition 18 crew members and Simonyi depart the station.

The Expedition 19 crew will work with experiments across a wide variety of fields, including human life sciences, physical sciences and Earth observation, and conduct technology demonstrations. As with prior Expeditions, many experiments are designed to gather information about the effects of long-duration spaceflight on the human body, which will help with planning future exploration missions to the moon and Mars. The crew also will conduct experiments in tandem with various science teams and classrooms on the ground, including the EarthKAM project. EarthKAM allows middle school students to program a camera on board the station to take requested photos of the planet below. The camera operates automatically, and the images are downlinked to the students via the Web.

Soon after arriving, the Expedition 19 crew will prepare for the May undocking of the Progress 32 cargo craft and the arrival and docking of the Progress 33 resupply vehicle. They also will spend time performing checkout procedures of the Advanced Resistive Exercise Device, or ARED, which is one of the three exercise devices on board the station. The crew will continue to prepare the regenerative environmental equipment for the increase in crew size that will take place in May. This activity will include ensuring the Water Reclamation System, or WRS, is ready for full use.


***Astronaut Michael Barratt, NASA Expedition 19 flight engineer, undergoes a pressure and leak check on his Russian launch and entry suit at the Baikonur Cosmodrome in Kazakhstan (March 12, 2009).***

***Astronauts Michael Barratt (foreground) and Tim Kopra, both Expedition 19/20 flight engineers, look over procedures checklists during a training session in an International Space Station mock-up/trainer in the Space Vehicle Mockup Facility at NASA's Johnson Space Center.***

On May 27, cosmonaut Roman Romanenko (Ro-mun-NEHN'-ko), a 37-year-old Russian Air Force lieutenant colonel, Canadian Space Agency astronaut Robert Thirsk (THURSK), 55, and European Space Agency astronaut Frank De Winne (Duh-WIN'-nuh), 48, will launch from Baikonur aboard the Soyuz TMA-15 spacecraft. They will dock with the Zarya module of the space station May 29, inaugurating the long-awaited presence of a six-person crew on the station. It also will mark the moment when all five partner agencies are represented by crew members on the orbiting laboratory and will begin what is called Expedition 20, still under the command of Padalka. Romanenko, the Soyuz TMA-15 commander, will serve as a station flight engineer in his first flight into space.

Thirsk is making his second flight into space, having flown aboard shuttle Columbia in 1996 on a Spacelab science mission. Thirsk will become the first Canadian to fly on a long-duration spaceflight. He is scheduled to return to Earth in the fall on shuttle Atlantis at the conclusion of the STS-129 mission. De Winne also is making his second flight into space.

Within days of the arrival of Expedition 20, Padalka and Barratt are scheduled to complete two spacewalks in Russian Orlan spacesuits to add hardware and reposition equipment on the Pirs Docking Compartment in preparation for the Mini Research Module-2, or MRM-2, a new Russian docking and research module, later in the year.


***Canadian Space Agency astronaut Robert Thirsk, Expedition 20/21 flight engineer, dons a training version of the shuttle launch and entry suit in preparation for a water survival training session in the Neutral Buoyancy Laboratory (NBL) near NASA's Johnson Space Center. United Space Alliance (USA) suit technician Drew Billingsley assists Thirsk.***

On the heels of the two spacewalks, shuttle Endeavour is targeted to launch on its STS-127 mission to the station. This flight will deliver the Japanese Experiment Module-Exposed Facility and the Japanese Experiment Logistics Module-Exposed Section for the Kibo laboratory. The exposed section is a “front porch” on which experiments will be mounted for long-duration exposure to the environment in low Earth orbit. The shuttle also will deliver some spare parts for the station and install new batteries in the P6 Truss.

The mission also will deliver NASA astronaut Tim Kopra (KOH'-pruh), a 46-year-old Army colonel, to the complex to replace Wakata, who will return to Earth aboard Endeavour. Kopra is making his first flight into space and will remain on board the station until August when he is scheduled to come home on Discovery’s STS-128 mission that will deliver his replacement, Nicole Stott (STAHTT), 46. She will spend a little more than three months in orbit and is slated to return to Earth with Romanenko and De Winne on the Soyuz TMA-15 in late November.

Once the Progress 33 undocks from Pirs in July, Padalka, Barratt and Kopra will don their launch and landing suits and board the Soyuz TMA-14 for a brief trip to relocate their return craft from Zvezda to Pirs. Romanenko, Thirsk and De Winne will monitor the operation from inside the station. This will clear the way for the docking of the Progress 34 cargo vehicle to Zvezda at the end of the month. A total of five Russian Progresses will make space station resupply missions this year.

***Astronaut Michael Barratt, Expedition 19/20 flight engineer, participates in an Extravehicular Mobility Unit (EMU) spacesuit fit check in the Space Station Airlock Test Article (SSATA) in the Crew Systems Laboratory at NASA’s Johnson Space Center. Astronauts Nicole Stott, Expedition 20/21 flight engineer, and Mike Fossum (support crew member) assist\ Barratt.***

August will bring the docking of shuttle Discovery on the STS-128 mission. This flight will carry a Multipurpose Logistics Module, or MPLM, which will contain supplies and equipment necessary to maintain the six-person crew aboard the station. The crew will remove a materials processing experiment and a European science experiment mounted outside the Columbus module and will remove and replace an empty ammonia tank assembly during the mission's three spacewalks.

September will see the inaugural launch of the Japan Aerospace Exploration Agency's H-II Transfer Vehicle, or HTV, cargo craft. The unpiloted spacecraft will launch from the Tanegashima Space Center in Japan and will fly just close enough to the International Space Station for the station's arm to reach out and capture it. The arm will then be used to dock the HTV with the Earth-facing port of the Harmony node, where it will deliver approximately six tons of supplies for the crew.

***Astronaut Robert Thirsk, Expedition 20/21 flight engineer representing the Canadian Space Agency (CSA), participates in a Microgravity Science Glovebox (MSG) operations training session in the Jake Garn Simulation and Training Facility at NASA's Johnson Space Center.***

The HTV joins the Russian Progress and European Automated Transfer Vehicle as cargo vessels designed to keep the station supplied with critical hardware for day-to-day operations. After a month attached to the outpost, the Canadarm2 will unberth the HTV, enabling it to fire its engines to back away from the station and conduct a deorbit maneuver, allowing it to burn up in the Earth's atmosphere.

In late September, NASA astronaut Jeff Williams, 51, a retired Army colonel and station veteran, and cosmonaut Max Suraev, 37, a Russian Air Force colonel, will launch from the Baikonur Cosmodrome on the Soyuz TMA-16, presumably with a Kazakh spaceflight participant, to replace Padalka and Barratt and begin Expedition 21 under De Winne's command at the point at which Padalka, Barratt and the Kazakh cosmonaut land in the Soyuz TMA-14 craft in mid-October. Williams takes over as Expedition 22 commander with Suraev operating as flight engineer when Romanenko, De Winne and Stott depart in late November.

# Expedition 19 & 20 Crew

## Expedition 19


***Expedition 19 Patch***

Expedition 19 marks the final planned period of three-person occupancy before increasing the crew size to six, and it occurs in the final stages of International Space Station assembly. The patch emphasizes Earth, one of the major focuses of attention and study from the orbital research outpost. The design is stylized to highlight the beauty of the home planet and the station orbiting it, next to the sun, now the unquestioned brightest star in the sky as viewed from Earth.


***Cosmonaut Gennady Padalka (center), Expedition 19 and 20 commander; NASA astronaut Michael Barratt (left) and Japan Aerospace Exploration Agency (JAXA) astronaut Koichi Wakata, both flight engineers, take a break from training at NASA's Johnson Space Center in Houston to pose for a crew portrait. Padalka and Barratt are scheduled to launch to the International Space Station in the Soyuz TMA-14 spacecraft from the Baikonur Cosmodrome in Kazakhstan in March 2009. Wakata will fly to the station on STS-119 and will serve as a flight engineer for Expeditions 18, 19 and 20.***

# Expedition 20


***Expedition 20 Patch***

The Expedition 20 patch symbolizes a new era in space exploration with the first six-person crew living and working aboard the space station, and it represents the significance of the station to the exploration goals of NASA and its international partners. The six gold stars signify the men and women of the crew. The astronaut symbol extends from the base of the patch to the star at the top to represent the international team, both on the ground and in orbit, who are working together to further our knowledge of living and working in space. The space station in the foreground represents where we are now and the important role it is playing toward meeting our exploration goals. The knowledge and expertise developed from these advancements will enable us to leave low Earth orbit once again for the new challenges of establishing a permanent presence on the moon and traveling on to Mars and other destinations. The blue, gray and red arcs represent our exploration goals as symbols of Earth, the moon and Mars.


***Expedition 20 crew members take a break from training at NASA's Johnson Space Center to pose for a crew portrait. From the left (front row) are European Space Agency astronaut Frank De Winne, Expedition 20 flight engineer and Expedition 21 commander; cosmonaut Gennady Padalka, Expedition 19/20 commander; and cosmonaut Roman Romanenko, Expedition 20/21 flight engineer. From the left (back row) are Canadian Space Agency astronaut Robert Thirsk, Expedition 20/21 flight engineer; NASA astronauts Michael Barratt, Expedition 19/20 flight engineer; Nicole Stott, Expedition 20/21 flight engineer; Tim Kopra, Expedition 20 flight engineer; and Japan Aerospace Exploration Agency (JAXA) astronaut Koichi Wakata, 18/19/20 flight engineer.***

Three new crew members will join Padalka, Barratt and Wakata to comprise the Expedition 20 crew, the inauguration of six-person crews on the station. Russian cosmonaut Roman Romanenko, European Space Agency astronaut Frank De Winne and Canadian Space Agency astronaut Robert Thirsk will arrive on a Soyuz spacecraft in May 2009. During the increment, space shuttle Endeavour is expected to arrive with the STS-127 crew, delivering NASA astronaut Tim Kopra and returning Wakata to Earth. Months later, Atlantis and the STS-128 crew will bring NASA astronaut Nicole Stott to the station and return Kopra to Earth.

Short biographical sketches of the crew follow with detailed background available at:

http://www.jsc.nasa.gov/Bios/

## Expedition 19

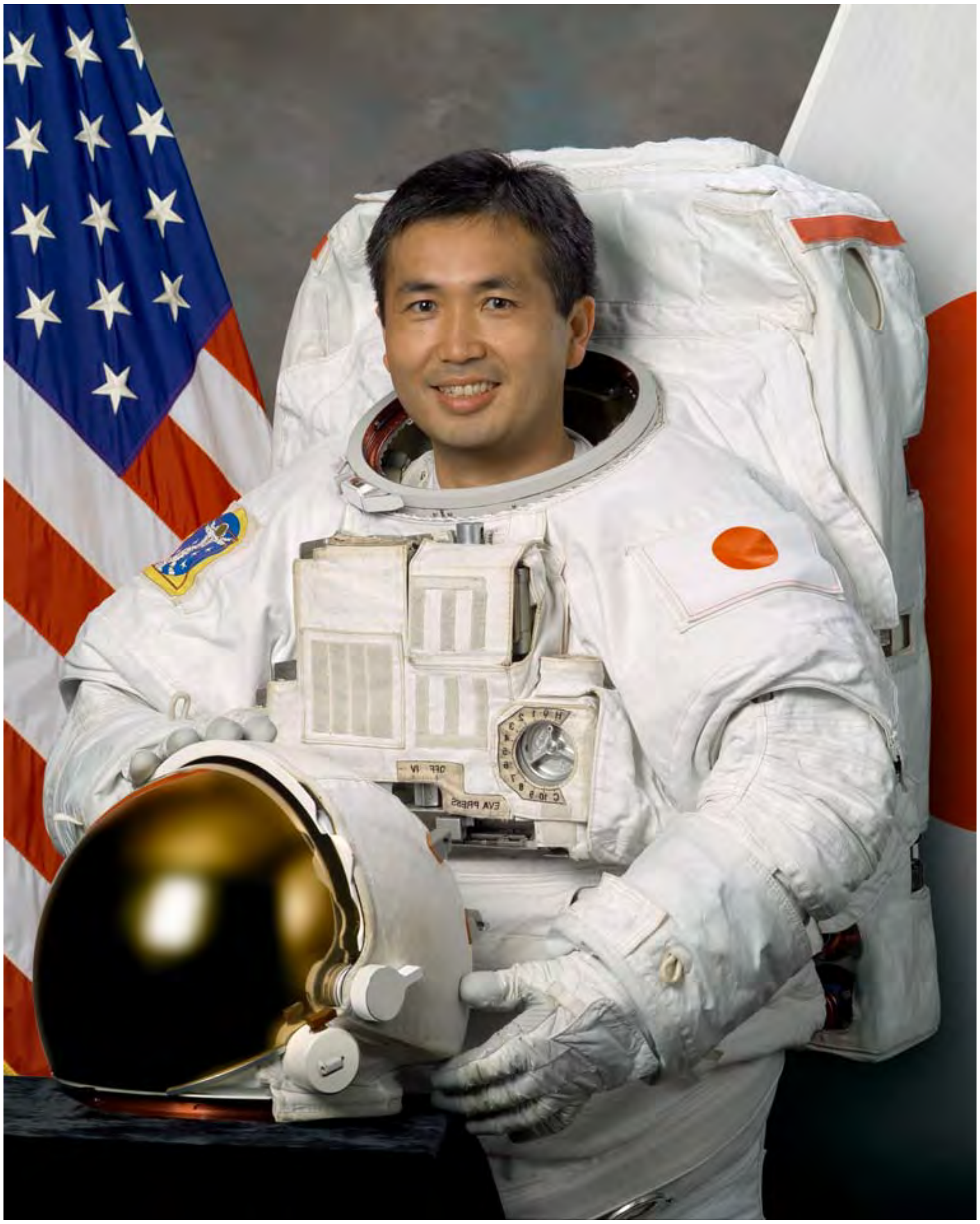

***Gennady Padalka***

A veteran of two prior long-duration missions, Gennady Padalka (Col., Russian Air Force) will lead the Expedition 19 crew as the Soyuz and station commander for the last three-person station crew. He also will serve as Expedition 20 commander. Padalka most recently served as the Expedition 9 commander, during which time he served with Expedition 18 Commander E. Michael Fincke for a six-month tour of duty. The two continued science operations, maintained station systems and performed four spacewalks. Previously Padalka served aboard the Soyuz-TM28 and space station Mir as the commander, logging 198 days in space.

He was selected as a cosmonaut candidate to start training at the Gagarin Cosmonaut Training Center in 1989. From June 1989 to January 1991, he attended basic space training. In 1991 Padalka was qualified as a test-cosmonaut.


***Michael Barratt***

Michael Barratt will be making his first trip to space. A native of the state of Washington, Barratt holds degrees from the University of Washington and a medical doctorate from Northwestern University. Additionally, he completed residency and a master's program in aerospace medicine and is board certified in internal and aerospace medicine. He began work at NASA's Johnson Space Center in 1991 as an aerospace project physician with KRUG Life Sciences. In 1992, he was assigned as a NASA flight surgeon, spending three years as a medical operations lead for the space station and the lead crew surgeon for first expedition crew to the space station. NASA selected Barratt as an astronaut candidate in July 2000. Following the completion of two years of training and evaluation, he was assigned technical duties in the Astronaut Office Station Operations Branch.



***Koichi Wakata***

Japan Aerospace Exploration Agency (JAXA) astronaut Koichi Wakata will fly to the station on STS-119 and join the Expedition 18 crew as a flight engineer. He holds a doctorate in aerospace engineering. The National Space Development Agency of Japan (NASDA) selected him as an astronaut candidate in 1992. Wakata has logged a total of 21 days, 19 hours, 41 minutes and 5 seconds in space from his two previous spaceflights on STS-72 and STS-92. He has been training for a long-duration expedition on the space station since 2001. He will be the first resident station crew member from JAXA. He will return to Earth on STS-127.


***Charles Simonyi***

Charles Simonyi will join Padalka and Barratt on their trip to the space station, flying as spaceflight participant. He will stay aboard the station and return with Expedition 18 Commander Fincke and Soyuz Commander Yury Lonchakov.

Simonyi previously flew to the station in April 2007 as a spaceflight participant. He was born in Budapest, Hungary, and moved to the United States in 1968. He earned his bachelor's degree in engineering and mathematics from the University of California at Berkeley and his doctorate in computer science from Stanford University. From 1972 to 1980, he worked at Xerox Corp. In 1981, he joined Microsoft, where he worked for 20 years developing software. Simonyi left Microsoft in August 2002 to found Intentional Software Corp., a software engineering firm. The company is based in Bellevue, Wash. Simonyi gained his American citizenship in 1982.

## Expedition 20

***Tim Kopra***

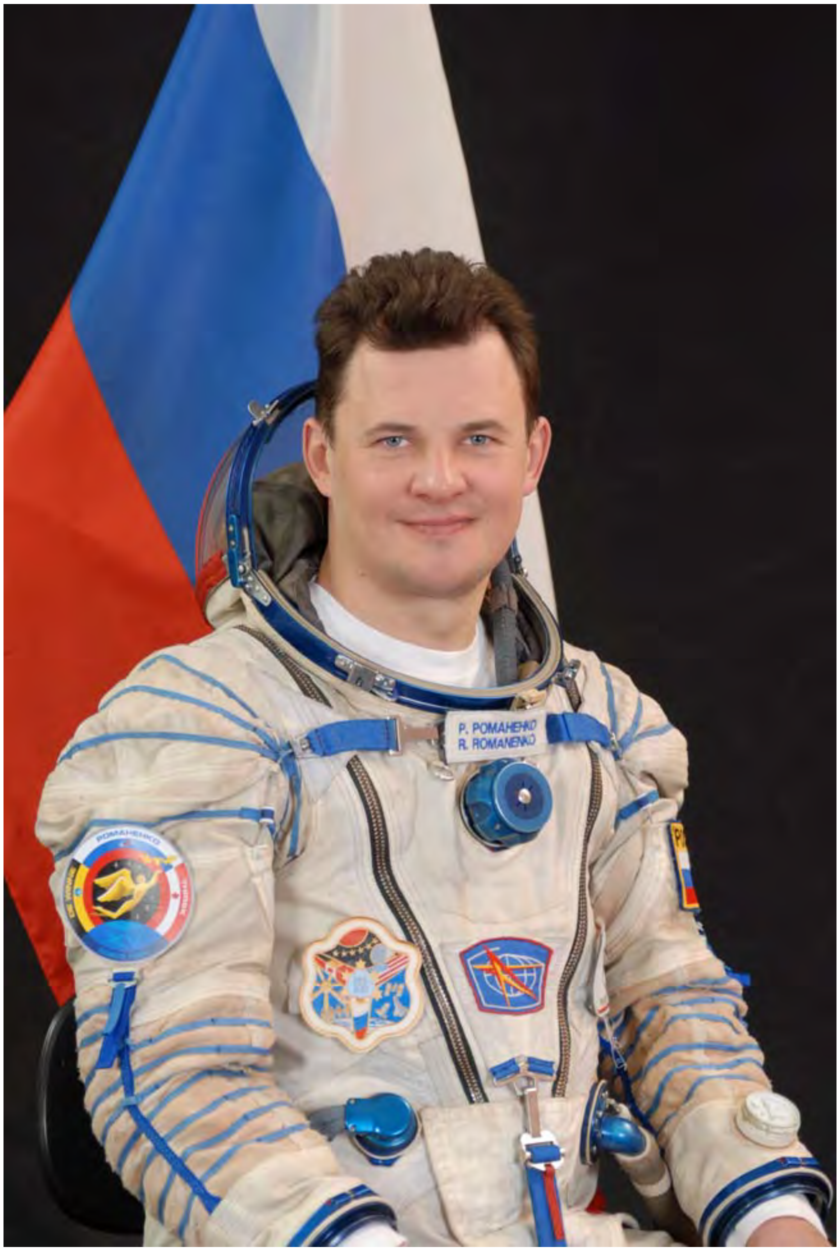
This will be the first spaceflight for Tim Kopra (Col, U.S. Army), who is a native of Austin, Texas.

A graduate of West Point, Kopra joined NASA's Johnson Space Center in September 1998 as a vehicle integration test engineer, serving as an engineering liaison for space shuttle launch operations and station hardware testing. He was actively involved in the contractor tests of the extravehicular activity interfaces for each of the space station truss segments. He was selected as an astronaut in July 2000. After initial training, he served in the Space Station Branch of the Astronaut Office, where his primary focus involved the testing of crew interfaces for two station modules as well as the implementation of support computers and an operational Local Area Network.

***Nicole Stott***

Nicole Stott joined NASA's Kennedy Space Center in 1988 as an operations engineer in the Orbiter Processing Facility before being promoted to vehicle flow director for Endeavour and orbiter test engineer for Columbia. During her last two years at Kennedy, she served as the NASA project lead for the space station truss elements under construction at the Boeing Space Station facility.

In 1998, she joined NASA's Johnson Space Center team in Houston as a member of the NASA Aircraft Operations Division, where she served as a flight simulation engineer on the Shuttle Training Aircraft. She was selected as a NASA astronaut in July 2000 and, after initial training, was assigned to the Astronaut Office Station Operations Branch, where she performed crew evaluations of station payloads. She also worked as a support astronaut and capsule communicator for the space station Expedition 10 crew. In April 2006 she was a crew member on the NASA Extreme Environment Mission Operations, or NEEMO, 9 mission. She lived and worked with a six-person crew for 18 days on the Aquarius undersea research habitat.




***Roman Romanenko***

This is the first mission for cosmonaut Roman Romanenko (Lt. Col., Russian Air Force), who will serve as Soyuz commander and flight engineer for Expedition 20. Born in the Schelkovo, Moscow Region, Romanenko graduated from pilot school and served as a second commander in the Air Force. He flew L-39 and Tu-134 aircraft, logging more than 500 hours of flight time. He was selected as a test-cosmonaut candidate of the Gagarin Cosmonaut Training Center Cosmonaut Office in December 1997. From January 1998 to November 1999, he completed his basic training course and qualified as a test cosmonaut in November 1999.

***Frank De Winne***

European Space Agency (ESA) astronaut Frank De Winne will serve as commander of Expedition 21. Born in Ghent, Belgium, De Winne received a master's degree in telecommunications and civil engineering from the Royal Military Academy, Brussels, in 1984 and, in 1992, graduated from the Empire Test Pilots School (ETPS) in Boscombe Down, England. Since then, De Winne has logged more than 2,300 hours flying in several types of high-performance aircraft, including Mirage, F16, Jaguar and Tornado.

De Winne joined the ESA Astronaut Corps in 2000 and two years later flew on a Soyuz to the space station as part of the Odissea mission. During his nine-day stay, he carried out 23 experiments in the fields of life and physical sciences and education. Later this year, he will serve as the first ESA commander of the space station during the Expedition 21 increment.


***Robert Thirsk***

Canadian Space Agency (CSA) astronaut Robert Thirsk is a spaceflight veteran, and like Barratt, holds a medical degree. He was selected to the CSA astronaut program in 1983 and has been involved in various CSA projects, including parabolic flight campaigns and mission planning. He served as crew commander for two space mission simulations: the seven-day CAPSULS mission in 1994 at Defense Research and Development Canada in Toronto; and the 11-day NEEMO 7 undersea mission in 2004 at the National Undersea Research Center in Key Largo, Fla.

In 1996, Thirsk flew as a payload specialist aboard space shuttle mission STS-78, the Life and Microgravity Spacelab mission. During the 17-day flight aboard shuttle Columbia, he and his six crewmates performed 43 international experiments devoted to the study of life and materials sciences.

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# Expedition 19/20 Major Milestones

**(Dates are subject to change)**

## 2009:

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| March 26 | Launch of the Expedition 19 crew (Padalka, Barratt) and U.S. spaceflight participant (Simonyi) from the Baikonur Cosmodrome, Kazakhstan, on Soyuz TMA-14 |
| March 28 | Expedition 19 docks to the International Space Station's Zvezda service module in Soyuz TMA-14 with U.S. spaceflight participant |
| April 2 | Change of command ceremony with departing Expedition 18 crew; Padalka becomes space station commander for Expeditions 19 and 20 |
| April 7 | Undocking of Expedition 18 crew (Lonchakov, Fincke) and U.S. spaceflight participant (Simonyi) from Zarya module and landing in Kazakhstan on Soyuz TMA-13; Expedition 19 formally begins |
| May 6 | Undocking of ISS Progress 32 cargo ship from the Pirs docking compartment |
| May 7 | Launch of the ISS Progress 33 cargo ship from the Baikonur Cosmodrome in Kazakhstan |
| May 12 | Docking of the ISS Progress 33 cargo ship to the Pirs docking compartment |
| May 27 | Launch of the Expedition 20/21 crew (Romanenko, DeWinne, Thirsk) from the Baikonur Cosmodrome in Kazakhstan on Soyuz TMA-15 |
| May 29 | Docking of the Expedition 20 crew and Soyuz TMA-15 to the Zarya module; beginning of the six-person crew on International Space Station as Expedition 19 becomes Expedition 20 |
| June 5 | Russian spacewalk by Padalka and Barratt in Orlan suits to install equipment on the top-facing side of the Zvezda service module to prepare for the docking of the new Mini-Research Module-2 (MRM2) and retrieval of science hardware |
| June 10 | Internal Russian spacewalk in the docking cone connecting the Zvezda and Zarya modules to reposition docking hardware for the arrival of MRM2 |
| June 13 | Targeted launch of Endeavour on the STS-127/2JA mission from the Kennedy Space Center |

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| June 15 | Docking of Endeavour to ISS Pressurized Mating Adapter-2 (PMA-2); Kopra and Wakata swap places as Expedition 20 crew members |
| June 26 | Undocking of Endeavour from ISS PMA-2 |
| June 29 | Landing of Endeavour to complete STS-127/2JA |
| Early July | Relocation of PMA-3 from Unity nadir to Unity port to prepare for the arrival of the Node 3/Cupola in 2010 |
| July 17 | Undocking of ISS Progress 33 from the Pirs docking compartment |
| July 20 | Relocation of the Soyuz TMA-14 from the Zvezda service module aft port to the Pirs docking compartment with Padalka, Barratt and Kopra aboard the Soyuz; Romanenko, De Winne and Thirsk remain aboard station during the relocation |
| July 24 | Launch of ISS Progress 34 from the Baikonur Cosmodrome in Kazakhstan |
| July 26 | Docking of ISS Progress 34 to the Zvezda service module aft port |
| Aug. 6 | Targeted launch of Discovery on the STS-128/17A mission from the Kennedy Space Center |
| Aug. 8 | Docking of Discovery to ISS Pressurized Mating Adapter-2 (PMA-2); Stott and Kopra swap places as Expedition 20 crew members |
| Aug. 17 | Undocking of Discovery from ISS PMA-2 |
| Aug. 19 | Landing of Discovery to complete STS-128/17A |
| Sept. 1 | Launch of the H-II Transfer Vehicle (HTV-1) cargo ship from the Tanegashima Space Center, Japan |
| Sept. 7 | Grapple of the HTV-1 by Canadarm2 |
| Sept. 8 | Berthing of the HTV-1 to the Harmony Node earth-facing port |
| Sept. 29 | Undocking of ISS Progress 34 from the Zvezda service module aft port |
| Sept. 30 | Launch of the Expedition 21/22 crew (Suraev, J. Williams) and a Kazakh spaceflight participant from the Baikonur Cosmodrome in Kazakhstan on Soyuz TMA-16 |
| Oct. 2 | Docking of the Expedition 21/22 crew and Soyuz TMA-16 to the Zvezda service module aft port; the crew joins Expedition 20 for a total of nine crew members on the station for nine days |

| | |
|---|---|
| Oct. 8 | Canadarm 2 grapples HTV-1 and unberths it from the Harmony node's earth-facing port; HTV-1 is released for its deorbit burn and re-entry to burn up in Earth's atmosphere |
| Oct. 11 | Undocking of Expedition 20 crew (Padalka, Barratt) in Soyuz TMA-14 from Pirs Docking Compartment and landing in Kazakhstan with Kazakh spaceflight participant; Expedition 21 formally begins and De Winne takes over as the European Space Agency's first commander of the space station. |

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# Expedition 19/20 Spacewalks

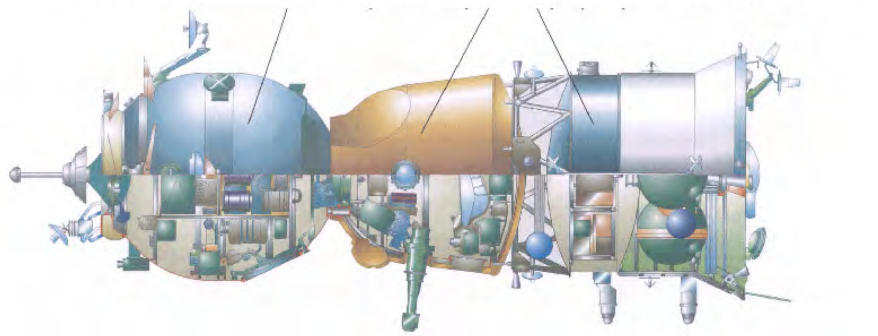
There are no U.S.-based spacewalks currently scheduled for Expedition 19 or 20. However, Commander Gennady Padalka and Flight Engineer Michael Barratt plan to don Russian Orlan spacesuits twice in June for the station's 22nd and 23rd Russian spacewalks. It will be Padalka's fifth and sixth spacewalks and Barratt's first and second.

The plans for the spacewalks are still in work, but several tasks already have been identified. During the first spacewalk, currently scheduled for June 5, Padalka and Barratt will start by attaching to the Zvezda service module an antenna that will be used to guide vehicles to the space station for docking. Before they wrap up their trip outside the station, they also will move a cable clamp, install a new EXPOSE-R science experiment on Zvezda and remove and store a Russian biomedical experiment.

For their second spacewalk, currently scheduled for June 10, Padalka and Barratt are not planning to actually leave the interior of the station. Instead, they will depressurize the small docking module that connects Zvezda to the Russian Zarya module and swap two hatches from its interior. One of the hatches has a docking cone attached to it that will be used to connect Russia's Mini Research Module 2 to the station when it is launched. However, the hatch with the docking cone is not on the side of the station that the module is intended to dock to, so the hatches will be swapped.


***Attired in a training version of his Extravehicular Mobility Unit spacesuit, astronaut Michael Barratt, Expedition 19/20 flight engineer, awaits the start of a spacewalk training session in the waters of the Neutral Buoyancy Laboratory near NASA's Johnson Space Center.***

# Russian Soyuz TMA




The Soyuz TMA spacecraft is designed to serve as the ISS's crew return vehicle, acting as a lifeboat in the unlikely event an emergency would require the crew to leave the station. A new Soyuz capsule is normally delivered to the station by a Soyuz crew every six months, replacing an older Soyuz capsule at the ISS.

The Soyuz spacecraft is launched to the space station from the Baikonur Cosmodrome in Kazakhstan aboard a Soyuz rocket. It consists of an orbital module, a descent module and an instrumentation/propulsion module.

## Orbital Module

This portion of the Soyuz spacecraft is used by the crew while on orbit during free-flight. It has a volume of 6.5 cubic meters (230 cubic feet), with a docking mechanism, hatch and rendezvous antennas located at the front end. The docking mechanism is used to dock with the space station and the hatch allows entry into the station. The rendezvous antennas are used by the automated docking system – a radar-based system – to maneuver towards the station for docking. There is also a window in the module.

The opposite end of the orbital module connects to the descent module via a pressurized hatch. Before returning to Earth, the orbital module separates from the descent module – after the deorbit maneuver – and burns up upon re-entry into the atmosphere.

## Descent Module

The descent module is where the cosmonauts and astronauts sit for launch, re-entry and landing. All the necessary controls and displays of the Soyuz are here. The module also contains life support supplies and batteries used during descent, as well as the primary and backup parachutes and landing rockets. It also contains custom-fitted seat liners for each crew member, individually molded to fit each person's body – this ensures a tight, comfortable fit when the module lands on the Earth. When crew members are brought to the station aboard the space shuttle, their seat liners are brought with them and transferred to the Soyuz spacecraft as part of crew handover activities.

The module has a periscope, which allows the crew to view the docking target on the station or the Earth below. The eight hydrogen peroxide thrusters located on the module are used to control the spacecraft's orientation, or attitude, during the descent until parachute deployment. It also has a guidance, navigation and control system to maneuver the vehicle during the descent phase of the mission.

This module weighs 2,900 kilograms (6,393 pounds), with a habitable volume of 4 cubic meters (141 cubic feet). Approximately 50 kilograms (110 pounds) of payload can be returned to Earth in this module and up to 150 kilograms (331 pounds) if only two crew members are present. The Descent Module is the only portion of the Soyuz that survives the return to Earth.

## Instrumentation/Propulsion Module

This module contains three compartments: intermediate, instrumentation and propulsion.

The intermediate compartment is where the module connects to the descent module. It also contains oxygen storage tanks and the attitude control thrusters, as well as electronics, communications and control equipment. The primary guidance, navigation, control and computer systems of the Soyuz are in the instrumentation compartment, which is a sealed container filled with circulating nitrogen gas to cool the avionics equipment. The propulsion compartment contains the primary thermal control system and the Soyuz radiator, with a cooling area of 8 square meters (86 square feet). The propulsion system, batteries, solar arrays, radiator and structural connection to the Soyuz launch rocket are located in this compartment.

The propulsion compartment contains the system that is used to perform any maneuvers while in orbit, including rendezvous and docking with the space station and the deorbit burns necessary to return to Earth. The propellants are nitrogen tetroxide and unsymmetric-dimethylhydrazine. The main propulsion system and the smaller reaction control system, used for attitude changes while in space, share the same propellant tanks.

The two Soyuz solar arrays are attached to either side of the rear section of the instrumentation/propulsion module and are linked to rechargeable batteries. Like the orbital module, the intermediate section of the instrumentation/propulsion module separates from the descent module after the final deorbit maneuver and burns up in atmosphere upon re-entry.

## TMA Improvements and Testing

The Soyuz TMA spacecraft is a replacement for the Soyuz TM, which was used from 1986 to 2002 to take astronauts and cosmonauts to Mir and then to the International Space Station.

The TMA increases safety, especially in descent and landing. It has smaller and more efficient computers and improved displays. In addition, the Soyuz TMA accommodates individuals as large as 1.9 meters (6 feet, 3 inches) tall and 95 kilograms (209 pounds), compared to 1.8 meters (6 feet) and 85 kilograms (187 pounds) in the earlier TM. Minimum crew member size for the TMA is 1.5 meters (4 feet, 11 inches) and 50 kilograms (110 pounds), compared to 1.6 meters (5 feet, 4 inches) and 56 kilograms (123 pounds) for the TM.

Two new engines reduce landing speed and forces felt by crew members by 15 to 30 percent and a new entry control system and three-axis accelerometer increase landing accuracy. Instrumentation improvements include a color "glass cockpit," which is easier to use and gives the crew more information, with hand controllers that can be secured under an instrument panel. All the new components in the Soyuz TMA can spend up to one year in space.

New components and the entire TMA were rigorously tested on the ground, in hangar-drop tests, in airdrop tests and in space before the spacecraft was declared flight-ready. For example, the accelerometer and associated software, as well as modified boosters (incorporated to cope with the TMA's additional mass), were tested on flights of Progress unpiloted supply spacecraft, while the new cooling system was tested on two Soyuz TM flights.

Descent module structural modifications, seats and seat shock absorbers were tested in hangar drop tests. Landing system modifications, including associated software upgrades, were tested in a series of airdrop tests. Additionally, extensive tests of systems and components were conducted on the ground.

## Soyuz Launcher

Throughout history, more than 1,500 launches have been made with Soyuz launchers to orbit satellites for telecommunications, Earth observation, weather, and scientific missions, as well as for human flights.

The basic Soyuz vehicle is considered a three-stage launcher in Russian terms and is composed of:

- A lower portion consisting of four boosters (first stage) and a central core (second stage).
- An upper portion, consisting of the third stage, payload adapter and payload fairing.
- Liquid oxygen and kerosene are used as propellants in all three Soyuz stages.

## First Stage Boosters

The first stage's four boosters are assembled around the second stage central core. The boosters are identical and cylindrical-conic in shape with the oxygen tank in the cone-shaped portion and the kerosene tank in the cylindrical portion.

An NPO Energomash RD 107 engine with four main chambers and two gimbaled vernier thrusters is used in each booster. The vernier thrusters provide three-axis flight control.

Ignition of the first stage boosters and the second stage central core occur simultaneously on the ground. When the boosters have completed their powered flight during ascent, they are separated and the core second stage continues to function.

First stage separation occurs when the pre-defined velocity is reached, which is about 118 seconds after liftoff.

***A Soyuz launches from the Baikonur Cosmodrome, Kazakhstan.***

## Second Stage

An NPO Energomash RD 108 engine powers the Soyuz second stage. This engine has four vernier thrusters, necessary for three-axis flight control after the first stage boosters have separated.

An equipment bay located atop the second stage operates during the entire flight of the first and second stages.

## Third Stage

The third stage is linked to the Soyuz second stage by a latticework structure. When the second stage's powered flight is complete, the third stage engine is ignited. Separation occurs by the direct ignition forces of the third stage engine.

A single-turbopump RD 0110 engine from KB KhA powers the Soyuz third stage.

The third stage engine is fired for about 240 seconds. Cutoff occurs at a calculated velocity. After cutoff and separation, the third stage performs an avoidance maneuver by opening an outgassing valve in the liquid oxygen tank.

## Launcher Telemetry Tracking & Flight Safety Systems

Soyuz launcher tracking and telemetry is provided through systems in the second and third stages. These two stages have their own radar transponders for ground tracking. Individual telemetry transmitters are in each stage. Launcher health status is downlinked to ground stations along the flight path. Telemetry and tracking data are transmitted to the mission control center, where the incoming data flow is recorded. Partial real-time data processing and plotting is performed for flight following and initial performance assessment. All flight data is analyzed and documented within a few hours after launch.

## Baikonur Cosmodrome Launch Operations

Soyuz missions use the Baikonur Cosmodrome's proven infrastructure, and launches are performed by trained personnel with extensive operational experience.

Baikonur Cosmodrome is in the Republic of Kazakhstan in Central Asia between 45 degrees and 46 degrees north latitude and 63 degrees east longitude. Two launch pads are dedicated to Soyuz missions.

## Final Launch Preparations

The assembled launch vehicle is moved to the launch pad on a railcar. Transfer to the launch zone occurs two days before launch. The vehicle is erected and a launch rehearsal is performed that includes activation of all electrical and mechanical equipment.

On launch day, the vehicle is loaded with propellant and the final countdown sequence is started at three hours before the liftoff time.

## Rendezvous to Docking

A Soyuz spacecraft generally takes two days to reach the space station. The rendezvous and docking are both automated, though once the spacecraft is within 150 meters (492 feet) of the station, the Russian Mission Control Center just outside Moscow monitors the approach and docking. The Soyuz crew has the capability to manually intervene or execute these operations.

# Soyuz Booster Rocket Characteristics

| **First Stage Data - Blocks B, V, G, D** | |
|---|---|
| Engine | RD-107 |
| Propellants | LOX/Kerosene |
| Thrust (tons) | 102 |
| Burn time (sec) | 122 |
| Specific impulse | 314 |
| Length (meters) | 19.8 |
| Diameter (meters) | 2.68 |
| Dry mass (tons) | 3.45 |
| Propellant mass (tons) | 39.63 |
| **Second Stage Data, Block A** | |
| Engine | RD-108 |
| Propellants | LOX/Kerosene |
| Thrust (tons) | 96 |
| Burn time (sec) | 314 |
| Specific impulse | 315 |
| Length (meters) | 28.75 |
| Diameter (meters) | 2.95 |
| Dry mass (tons) | 6.51 |
| Propellant mass (tons) | 95.7 |
| **Third Stage Data, Block I** | |
| Engine | RD-461 |
| Propellants | LOX/Kerosene |
| Thrust (tons) | 30 |
| Burn time (sec) | 240 |
| Specific impulse | 330 |
| Length (meters) | 8.1 |
| Diameter (meters) | 2.66 |
| Dry mass (tons) | 2.4 |
| Propellant mass (tons) | 21.3 |
| PAYLOAD MASS (tons) | 6.8 |
| SHROUD MASS (tons) | 4.5 |
| LAUNCH MASS (tons) | 309.53 |
| TOTAL LENGTH (meters) | 49.3 |

## Prelaunch Countdown Timeline

| | |
|---|---|
| T- 34 Hours | Booster is prepared for fuel loading |
| T- 6:00:00 | Batteries are installed in booster |
| T- 5:30:00 | State commission gives go to take launch vehicle |
| T- 5:15:00 | Crew arrives at site 254 |
| T- 5:00:00 | Tanking begins |
| T- 4:20:00 | Spacesuit donning |
| T- 4:00:00 | Booster is loaded with liquid oxygen |
| T- 3:40:00 | Crew meets delegations |
| T- 3:10:00 | Reports to the State commission |
| T- 3:05:00 | Transfer to the launch pad |
| T- 3:00:00 | Vehicle 1st and 2nd stage oxidizer fueling complete |
| T- 2:35:00 | Crew arrives at launch vehicle |
| T- 2:30:00 | Crew ingress through orbital module side hatch |
| T- 2:00:00 | Crew in re-entry vehicle |
| T- 1:45:00 | Re-entry vehicle hardware tested; suits are ventilated |
| T- 1:30:00 | Launch command monitoring and supply unit prepared |
| | Orbital compartment hatch tested for sealing |
| T- 1:00:00 | Launch vehicle control system prepared for use; gyro instruments activated |
| T - :45:00 | Launch pad service structure halves are lowered |
| T- :40:00 | Re-entry vehicle hardware testing complete; leak checks performed on suits |
| T- :30:00 | Emergency escape system armed; launch command supply unit activated |
| T- :25:00 | Service towers withdrawn |
| T- :15:00 | Suit leak tests complete; crew engages personal escape hardware auto mode |
| T- :10:00 | Launch gyro instruments uncaged; crew activates on-board recorders |
| T- 7:00 | All prelaunch operations are complete |
| T- 6:15 | Key to launch command given at the launch site |
| | Automatic program of final launch operations is activated |
| T- 6:00 | All launch complex and vehicle systems ready for launch |
| T- 5:00 | Onboard systems switched to onboard control |
| | Ground measurement system activated by RUN 1 command |
| | Commander's controls activated |
| | Crew switches to suit air by closing helmets |
| | Launch key inserted in launch bunker |
| T- 3:15 | Combustion chambers of side and central engine pods purged with nitrogen |

## Prelaunch Countdown Timeline (concluded)

| | |
|---|---|
| T- 2:30 | Booster propellant tank pressurization starts |
| | Onboard measurement system activated by RUN 2 command |
| | Prelaunch pressurization of all tanks with nitrogen begins |
| T- 2:15 | Oxidizer and fuel drain and safety valves of launch vehicle are closed |
| | Ground filling of oxidizer and nitrogen to the launch vehicle is terminated |
| T- 1:00 | Vehicle on internal power |
| | Automatic sequencer on |
| | First umbilical tower separates from booster |
| T- :40 | Ground power supply umbilical to third stage is disconnected |
| T- :20 | Launch command given at the launch position |
| | Central and side pod engines are turned on |
| T- :15 | Second umbilical tower separates from booster |
| T- :10 | Engine turbopumps at flight speed |
| T- :05 | First stage engines at maximum thrust |
| T- :00 | Fueling tower separates |
| | Lift off |

## Ascent/Insertion Timeline

| | |
|---|---|
| T- :00 | Lift off |
| T+ 1:10 | Booster velocity is 1,640 ft/sec |
| T+ 1:58 | Stage 1 (strap-on boosters) separation |
| T+ 2:00 | Booster velocity is 4,921 ft/sec |
| T+ 2:40 | Escape tower and launch shroud jettison |
| T+ 4:58 | Core booster separates at 105.65 statute miles |
| | Third stage ignites |
| T+ 7:30 | Velocity is 19,685 ft/sec |
| T+ 9:00 | Third stage cut-off |
| | Soyuz separates |
| | Antennas and solar panels deploy |
| | Flight control switches to Mission Control, Korolev |

## Orbital Insertion to Docking Timeline

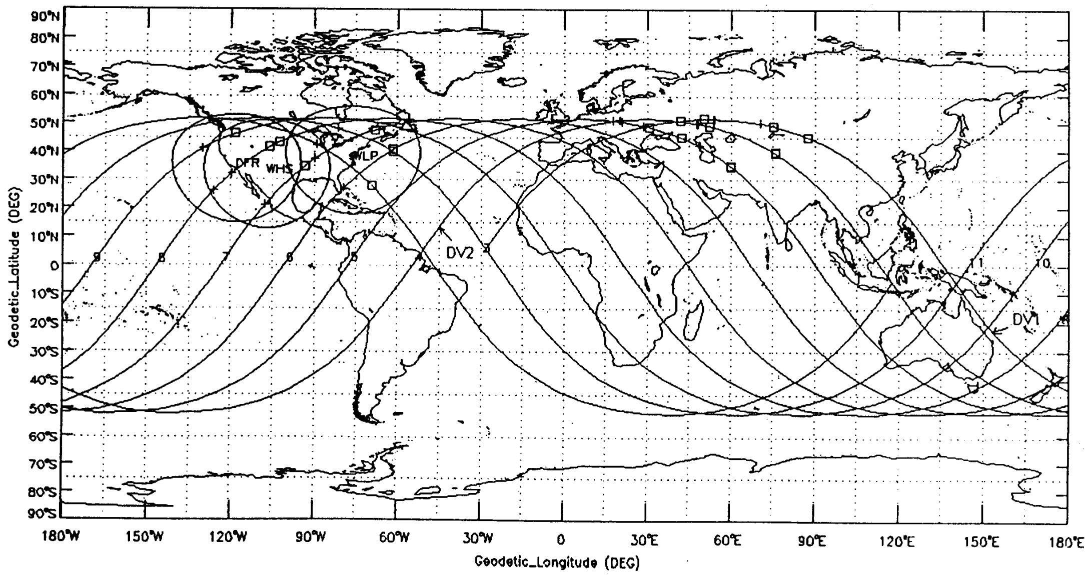
| FLIGHT DAY 1 OVERVIEW | |
|---|---|
| **Orbit 1** | **Post insertion: Deployment of solar panels, antennas and docking probe** |
| | - Crew monitors all deployments |
| | - Crew reports on pressurization of OMS/RCS and ECLSS systems and crew health. Entry thermal sensors are manually deactivated |
| | - Ground provides initial orbital insertion data from tracking |
| **Orbit 2** | **Systems Checkout: IR Att Sensors, Kurs, Angular Accels, "Display" TV Downlink System, OMS engine control system, Manual Attitude Control Test** |
| | - Crew monitors all systems tests and confirms onboard indications |
| | - Crew performs manual RHC stick inputs for attitude control test |
| | - Ingress into HM, activate HM CO2 scrubber and doff Sokols |
| | - A/G, R/T and Recorded TLM and Display TV downlink |
| | - Radar and radio transponder tracking |
| | **Manual maneuver to +Y to Sun and initiate a 2 deg/sec yaw rotation. MCS is deactivated after rate is established.** |
| **Orbit 3** | **Terminate +Y solar rotation, reactivate MCS and establish LVLH attitude reference (auto maneuver sequence)** |
| | - Crew monitors LVLH attitude reference build up |
| | - Burn data command upload for DV1 and DV2 (attitude, TIG Delta V's) |
| | - Form 14 preburn emergency deorbit pad read up |
| | - A/G, R/T and Recorded TLM and Display TV downlink |
| | - Radar and radio transponder tracking |
| | **Auto maneuver to DV1 burn attitude (TIG - 8 minutes) while LOS** |
| | - Crew monitor only, no manual action nominally required |
| | **DV1 phasing burn while LOS** |
| | - Crew monitor only, no manual action nominally required |
| **Orbit 4** | **Auto maneuver to DV2 burn attitude (TIG - 8 minutes) while LOS** |
| | - Crew monitor only, no manual action nominally required |
| | **DV2 phasing burn while LOS** |
| | - Crew monitor only, no manual action nominally required |

| FLIGHT DAY 1 OVERVIEW (CONTINUED) | |
|---|---|
| **Orbit 4 (continued)** | **Crew report on burn performance upon AOS** |
| | - HM and DM pressure checks read down |
| | - Post burn Form 23 (AOS/LOS pad), Form 14 and "Globe" corrections voiced up |
| | - A/G, R/T and Recorded TLM and Display TV downlink |
| | - Radar and radio transponder tracking |
| | **Manual maneuver to +Y to Sun and initiate a 2 deg/sec yaw rotation. MCS is deactivated after rate is established.** |
| | **External boresight TV camera ops check (while LOS)** |
| | **Meal** |
| **Orbit 5** | **Last pass on Russian tracking range for Flight Day 1** |
| | **Report on TV camera test and crew health** |
| | **Sokol suit clean up** |
| | - A/G, R/T and Recorded TLM and Display TV downlink |
| | - Radar and radio transponder tracking |
| **Orbit 6-12** | **Crew Sleep, off of Russian tracking range** |
| | - Emergency VHF2 comm available through NASA VHF Network |
| **FLIGHT DAY 2 OVERVIEW** | |
| **Orbit 13** | **Post sleep activity, report on HM/DM Pressures** |
| | **Form 14 revisions voiced up** |
| | - A/G, R/T and Recorded TLM and Display TV downlink |
| | - Radar and radio transponder tracking |
| **Orbit 14** | **Configuration of RHC-2/THC-2 work station in the HM** |
| | - A/G, R/T and Recorded TLM and Display TV downlink |
| | - Radar and radio transponder tracking |
| **Orbit 15** | **THC-2 (HM) manual control test** |
| | - A/G, R/T and Recorded TLM and Display TV downlink |
| | - Radar and radio transponder tracking |
| **Orbit 16** | **Lunch** |
| | - A/G, R/T and Recorded TLM and Display TV downlink |
| | - Radar and radio transponder tracking |
| **Orbit 17 (1)** | **Terminate +Y solar rotation, reactivate MCS and establish LVLH attitude reference (auto maneuver sequence)** |
| | **RHC-2 (HM) Test** |
| | - Burn data uplink (TIG, attitude, delta V) |
| | - A/G, R/T and Recorded TLM and Display TV downlink |
| | - Radar and radio transponder tracking |
| | **Auto maneuver to burn attitude (TIG - 8 min) while LOS** |
| | **Rendezvous burn while LOS** |
| | **Manual maneuver to +Y to Sun and initiate a 2 deg/sec yaw rotation. MCS is deactivated after rate is established.** |

| FLIGHT DAY 2 OVERVIEW (CONTINUED) | |
|---|---|
| **Orbit 18 (2)** | **Post burn and manual maneuver to +Y Sun report when AOS** |
| | - HM/DM pressures read down |
| | - Post burn Form 23, Form 14 and Form 2 (Globe correction) voiced up |
| | - A/G, R/T and Recorded TLM and Display TV downlink |
| | - Radar and radio transponder tracking |
| **Orbit 19 (3)** | **CO2 scrubber cartridge change out** |
| | **Free time** |
| | - A/G, R/T and Recorded TLM and Display TV downlink |
| | - Radar and radio transponder tracking |
| **Orbit 20 (4)** | **Free time** |
| | - A/G, R/T and Recorded TLM and Display TV downlink |
| | - Radar and radio transponder tracking |
| **Orbit 21 (5)** | **Last pass on Russian tracking range for Flight Day 2** |
| | **Free time** |
| | - A/G, R/T and Recorded TLM and Display TV downlink |
| | - Radar and radio transponder tracking |
| **Orbit 22 (6) - 27 (11)** | **Crew sleep, off of Russian tracking range** |
| | - Emergency VHF2 comm available through NASA VHF Network |
| **FLIGHT DAY 3 OVERVIEW** | |
| **Orbit 28 (12)** | **Post sleep activity** |
| | - A/G, R/T and Recorded TLM and Display TV downlink |
| | - Radar and radio transponder tracking |
| **Orbit 29 (13)** | **Free time, report on HM/DM pressures** |
| | - Read up of predicted post burn Form 23 and Form 14 |
| | - A/G, R/T and Recorded TLM and Display TV downlink |
| | - Radar and radio transponder tracking |
| **Orbit 30 (14)** | **Free time, read up of Form 2 "Globe Correction," lunch** |
| | - Uplink of auto rendezvous command timeline |
| | - A/G, R/T and Recorded TLM and Display TV downlink |
| | - Radar and radio transponder tracking |
| **FLIGHT DAY 3 AUTO RENDEZVOUS SEQUENCE** | |
| **Orbit 31 (15)** | **Don Sokol spacesuits, ingress DM, close DM/HM hatch** |
| | - Active and passive vehicle state vector uplinks |
| | - A/G, R/T and Recorded TLM and Display TV downlink |
| | - Radio transponder tracking |

| FLIGHT DAY 3 AUTO RENDEZVOUS SEQUENCE (CONCLUDED) | |
|---|---|
| **Orbit 32 (16)** | **Terminate +Y solar rotation, reactivate MCS and establish LVLH attitude reference (auto maneuver sequence)** |
| | **Begin auto rendezvous sequence** |
| | - Crew monitoring of LVLH reference build and auto rendezvous timeline execution |
| | - A/G, R/T and Recorded TLM and Display TV downlink |
| | - Radio transponder tracking |
| **FLIGHT DAY 3 FINAL APPROACH AND DOCKING** | |
| **Orbit 33 (1)** | **Auto Rendezvous sequence continues, flyaround and station keeping** |
| | - Crew monitor |
| | - Comm relays via SM through Altair established |
| | - Form 23 and Form 14 updates |
| | - Fly around and station keeping initiated near end of orbit |
| | - A/G (gnd stations and Altair), R/T TLM (gnd stations), Display TV downlink (gnd stations and Altair) |
| | - Radio transponder tracking |
| **Orbit 34 (2)** | **Final Approach and docking** |
| | - Capture to “docking sequence complete” 20 minutes, typically |
| | - Monitor docking interface pressure seal |
| | - Transfer to HM, doff Sokol suits |
| | - A/G (gnd stations and Altair), R/T TLM (gnd stations), Display TV downlink (gnd stations and Altair) |
| | - Radio transponder tracking |
| **FLIGHT DAY 3 STATION INGRESS** | |
| **Orbit 35 (3)** | **Station/Soyuz pressure equalization** |
| | - Report all pressures |
| | - Open transfer hatch, ingress station |
| | - A/G, R/T and playback telemetry |
| | - Radio transponder tracking |

## Typical Soyuz Ground Track



## Key Times for Expedition 19/18 International Space Station Events

**Expedition 19/Spaceflight Participant (SFP) Launch on Soyuz TMA-14**

6:49:10 a.m CT on March 26

11:49:10 GMT on March 26

14:49:10 p.m. Moscow time on March 26

17:49:10 p.m. Baikonur time on March 26 (about 2:19 before sunset)

**Expedition 19/SFP Docking to International Space Station on Soyuz TMA-14 (Zvezda Service Module aft port)**

8:14 a.m. CT on March 28

13:14 GMT on March 28

16:14 p.m. Moscow time on March 28

**Expedition 19/SFP Hatch Opening to International Space Station**

11:10 a.m. CT on March 28

16:10 GMT on March 28

19:10 p.m. Moscow time on March 28

**(Moscow moves to Daylight Savings Time on Sunday, March 29)**

**Expedition 18/SFP Hatch Closing to International Space Station**

9 p.m. CT on April 6

2:00 GMT on April 7

6 a.m. Moscow time on April 7

8 a.m. Kazakhstan time on April 7

**Expedition 18/SFP Undocking from International Space Station on Soyuz TMA-13 (Zarya module nadir port)**

12:02 a.m. CT on April 7

5:02 GMT on April 7

9:02 a.m. Moscow time on April 7

11:02 a.m. Kazakhstan time on April 7

**Expedition 18/SFP Deorbit Burn on Soyuz TMA-13**

2:29 a.m. CT on April 7

7:29 GMT on April 7

11:29 a.m. Moscow time on April 7

13:29 p.m. Kazakhstan time on April 7

**Expedition 18/SFP Landing in Soyuz TMA-13**

3:20:24 a.m. CT on April 7

8:20:24 GMT on April 7

12:20:24 p.m. Moscow time on April 7

14:20:24 p.m. Kazakhstan time on April 7 (5:54 before sunset at the landing site)

## Expedition 18/Soyuz TMA-13 Landing


***Astronaut E. Michael Fincke (right), Expedition 18 commander; astronaut Sandra Magnus and cosmonaut Yury Lonchakov, both flight engineers, pose for a crew photo between a Russian Orlan spacesuit and an Extravehicular Mobility Unit spacesuit in the Harmony node of the International Space Station.***

After a 10-day handover with the newly-arrived Expedition 19 crew, Expedition 18 Soyuz Commander Yury Lonchakov, Expedition 18 Commander E. Michael Fincke and U.S. spaceflight participant Charles Simonyi will board their Soyuz TMA-13 capsule for undocking and a one-hour descent back to Earth. Fincke and Lonchakov will complete a six-month mission in orbit, while Simonyi will return after a 12-day flight.

About three hours before undocking, Fincke, Lonchakov and Simonyi will bid farewell to the new Expedition 19 crew, Commander Gennady Padalka and Flight Engineers Michael Barratt and Koichi Wakata. Padalka and Barratt are launching to the International Space Station from the Baikonur Cosmodrome in Kazakhstan on the Soyuz TMA-14 vehicle. Wakata arrived at the station in March on the shuttle Discovery. The departing crew will climb into the Soyuz vehicle and close the hatch between Soyuz and the Zarya module. Fincke will be seated in the Soyuz' left seat for entry and landing as onboard engineer. Soyuz Commander Lonchakov will be in the center seat, as he was for launch back in October 2008, and Simonyi will occupy the right seat.

After activating Soyuz systems and getting approval from flight controllers at the Russian Mission Control Center outside Moscow, Lonchakov will send commands to open hooks and latches between Soyuz and Zarya.

Lonchakov will fire the Soyuz thrusters to back away from Zarya. Six minutes after undocking, with the Soyuz about 66 feet away from the station, Lonchakov will conduct a separation maneuver, firing the Soyuz jets for about 15 seconds to begin to depart the vicinity of the complex.

About 2.5 hours after undocking, at a distance of about 12 miles from the station, Soyuz computers will initiate a deorbit burn braking maneuver. The 4.5-minute maneuver to slow the spacecraft will enable it to drop out of orbit and begin its re-entry to Earth.

About 30 minutes later, just above the first traces of the Earth's atmosphere, computers will command the pyrotechnic separation of the three modules of the Soyuz vehicle. With the crew strapped in the descent module, the uppermost orbital module, containing the docking mechanism and rendezvous antennas, and the instrumentation and propulsion module at the rear, which houses the engines and avionics, will separate and burn up in the atmosphere.

The descent module's computers will orient the capsule with its ablative heat shield pointing forward to repel the buildup of heat as it plunges into the atmosphere. The crew will feel the first effects of gravity about three minutes after module separation at the point called entry interface, when the module is about 400,000 feet above the Earth.

About eight minutes later, at an altitude of about 33,000 feet, traveling at about 722 feet per second, the Soyuz will begin a computer-commanded sequence for the deployment of the capsule's parachutes. First, two "pilot" parachutes will be deployed, extracting a larger drogue parachute, which stretches out over an area of 79 square feet. Within 16 seconds, the Soyuz' descent will slow to about 262 feet per second.

The initiation of the parachute deployment will create a gentle spin for the Soyuz as it dangles underneath the drogue chute, assisting in the capsule's stability in the final minutes before touchdown.

A few minutes before touchdown, the drogue chute will be jettisoned, allowing the main parachute to be deployed. Connected to the descent module by two harnesses, the main parachute covers an area of about 3,281 feet. The deployment of the main parachute slows the descent module to a velocity of about 23 feet per second. Initially, the descent module will hang underneath the main parachute at a 30-degree angle with respect to the horizon for aerodynamic stability. The bottommost harness will be severed a few minutes before landing, allowing the descent module to right itself to a vertical position through touchdown.

At an altitude of a little more than 16,000 feet, the crew will monitor the jettison of the descent module's heat shield, which will be followed by the termination of the aerodynamic spin cycle and the dissipation of any residual propellant from the Soyuz. Computers also will arm the module's seat shock absorbers in preparation for landing.

When the capsule's heat shield is jettisoned, the Soyuz altimeter is exposed to the surface of the Earth. Signals are bounced to the ground from the Soyuz and reflected back, providing the capsule's computers updated information on altitude and rate of descent.

At an altitude of about 39 feet, cockpit displays will tell Lonchakov to prepare for the soft landing engine firing. Just 3 feet above the surface, and just seconds before touchdown, the six solid propellant engines will be fired in a final braking maneuver. This will enable the Soyuz to settle down to a velocity of about 5 feet per second and land, completing its mission.

As always is the case, teams of Russian engineers, flight surgeons and technicians in fleets of MI-8 helicopters will be poised near the normal and "ballistic" landing zones, and midway in between, to enact the swift recovery of Fincke, Lonchakov and Simonyi once the capsule touches down.

A portable medical tent will be set up near the capsule in which the crew can change out of its launch and entry suits. Russian technicians will open the module's hatch and begin to remove the crew members. The crew will be seated in special reclining chairs near the capsule for initial medical tests and to begin readapting to Earth's gravity.

About two hours after landing, the crew will be assisted to the recovery helicopters for a flight back to a staging site in northern Kazakhstan, where local officials will welcome them. The crew then will board a Russian military plane and be flown to the Chkalovsky Airfield adjacent to the Gagarin Cosmonaut Training Center in Star City, Russia, where their families will meet them. In all, it will take around eight hours between landing and the return to Star City.

Assisted by a team of flight surgeons, Fincke and Lonchakov will undergo planned medical tests and physical rehabilitation. Simonyi's acclimation to Earth's gravity will take a much shorter period of time due to the brevity of his flight.

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***The Soyuz TMA-13 spacecraft approaches the International Space Station in October 2008, carrying NASA astronaut E. Michael Fincke, Expedition 18 commander; Russian Federal Space Agency cosmonaut Yury Lonchakov, Soyuz commander and flight engineer; and American spaceflight participant Richard Garriott.***

## Soyuz TMA-13 Entry Timeline

***Russian search and recovery crew members examine the Soyuz TMA-12 capsule after it landed on the steppes of Kazakhstan on Oct. 24, 2008, with cosmonauts Sergei Volkov and Oleg Kononenko, Expedition 17 commander and flight engineer, respectively; and American spaceflight participant Richard Garriott, ending a six-month mission for Volkov and Kononenko on the International Space Station and 12 days in space for Garriott under a commercial agreement with the Russian Federal Space Agency.***

This is the entry timeline for Soyuz TMA-13.

**Undocking Command to Begin to Open Hooks and Latches; Undocking Command + 0 mins.)**

11:59 p.m. CT on April 6

4:59 GMT on April 7

8:59 a.m. Moscow time on April 7

10:59 a.m. Kazakhstan time on April 7

**Hooks Opened/Physical Separation of Soyuz from Zarya module nadir port at .12 meter/sec.; Undocking Command + 3 mins.)**

12:02 a.m. CT on April 7

5:02 GMT on April 7

9:02 a.m. Moscow time on April 7

11:02 a.m. Kazakhstan time on April 7

**Separation Burn from ISS (15 second burn of the Soyuz engines, .65 meters/sec.; Soyuz distance from the ISS is ~20 meters)**

12:05 a.m. CT on April 7

5:05 GMT on April 7

9:05 a.m. Moscow time on April 7

11:05 a.m. Kazakhstan time on April 7

**Deorbit Burn (appx 4:22 in duration, 115.2 m/sec.; Soyuz distance from the ISS is ~12 kilometers; Undocking Command appx + ~2 hours, 30 mins.)**

2:29:01 a.m. CT on April 7

7:29:01 GMT on April 7

11:29:01 a.m. Moscow time on April 7

13:29:01 p.m. Kazakhstan time on April 7

**Separation of Modules (~23 mins. after Deorbit Burn; Undocking Command + ~2 hours, 57 mins.)**

2:54:36 a.m. CT on April 7

7:54:36 GMT on April 7

11:54:36 a.m. Moscow time on April 7

13:54:36 p.m. Kazakhstan time on April 7

**Entry Interface (400,000 feet in altitude; 3 mins. after Module Separation; 31 mins. after Deorbit Burn; Undocking Command + ~3 hours)**

2:57:33 a.m. CT on April 7

7:57:33 GMT on April 7

11:57:33 a.m. Moscow time on April 7

13:57:33 p.m. Kazakhstan time on April 7

**Command to Open Chutes (8 mins. after Entry Interface; 39 mins. after Deorbit Burn; Undocking Command + ~3 hours, 8 mins.)**

3:06:01 a.m. CT on April 7

8:06:01 GMT on April 7

12:06:01 p.m. Moscow time on April 7

14:06:01 p.m. Kazakhstan time on April 7

Two pilot parachutes are first deployed, the second of which extracts the drogue chute. The drogue chute is then released, measuring 24 square meters, slowing the Soyuz down from a descent rate of 230 meters/second to 80 meters/second.

The main parachute is then released, covering an area of 1,000 meters; it slows the Soyuz to a descent rate of 7.2 meters/second; its harnesses first allow the Soyuz to descend at an angle of 30 degrees to expel heat, then shifts the Soyuz to a straight vertical descent.

**Soft Landing Engine Firing (6 engines fire to slow the Soyuz descent rate to 1.5 meters/second just .8 meter above the ground)**

Landing – appx. 2 seconds

**Landing (~50 mins. after Deorbit Burn; Undocking Command + ~3 hours, 24 mins.)**

3:20:24 a.m. CT on April 7

8:20:24 GMT on April 7

12:20:24 p.m. Moscow time on April 7

14:20:24 p.m. Kazakhstan time on April 7 (5:54 before sunset at the landing site).

# First Expedition to Use Recycling System for Duration

The next International Space Station crew will be the first to use all of the newly installed environmental, life support and habitability equipment for the expedition's full term.

The Expedition 19 crew will benefit from the efforts of the STS-126 space shuttle crew to deliver – and the Expedition 18 crew to install and outfit – a water recycling system, a second toilet, an advanced exercise system, two crew quarters sleep stations and a kitchenette. The Expedition 19 crew will give the new equipment a full workout and continue stocking up on supplies and equipment to make sure the station is ready to support the first six-person crew this summer.

Thanks to the work of the Expedition 18 crew, both of the crew quarters that were delivered on STS-126 have been installed, checked out and are ready for use. Expedition 18 Commander E. Michael Fincke is using one of the two crew quarters installed in the Harmony module, but Flight Engineer Sandra Magnus decided not to move from her Temporary Sleep Station (TESS) in the Discovery Laboratory, because her time aboard the station is nearing its end. Expedition 19 Flight Engineer Koichi Wakata is expected to use the other crew quarters module in Harmony. A third crew quarters will be delivered on STS-128, which will provide a full complement of private living space for six-person crews. When all are delivered and installed, there will be two in the Harmony module, one in Kibo, one in Destiny and two in Zvezda.

Expedition 19 crew members will be able to work out on the new Advanced Resistive Exercise Device (ARED) that was delivered by the STS-126 crew and set up by Fincke. ARED increases the equipment available for the daily two-and-a-half hours of exercise each crew member is required to accomplish. The goal is to stay fit and protect against the potentially detrimental effects of long-duration spaceflight, such as bone mass and muscle density loss. Other exercise equipment includes the Treadmill Vibration Isolation System (TVIS) in Zvezda, two cycle ergometers for stationary bike riding, and the now-stowed Interim Resistive Exercise Device (IRED) that is available as a backup to ARED. A second treadmill will be added during the STS-128 mission.

The crew also will have access to a refrigerator, food warmer and ambient and hot water dispenser that were delivered on STS-126 and installed by the Expedition 18 crew. The current crew has been setting the refrigerator at about 40 degrees Fahrenheit and using it to chill drinks and help preserve fresh produce that is delivered by visiting crews and cargo ships.

Expedition 19 crew members also will have the luxury of an extra toilet, known as the Waste and Hygiene Compartment (WHC), which also was delivered on STS-126 and set up and tested by Expedition 18. The system is working well and capable of routing urine directly to the new water recycling system, or into Russian waste containers to be disposed of in departing Progress resupply vehicles.

The STS-126 crew also delivered and helped install a new Water Recovery System (WRS), a component of a comprehensive regenerative life support system for the station. The Oxygen Generation System (OGS), which was launched on space shuttle Discovery in July 2006, and the WRS form the core of NASA's Regenerative Environmental Control and Life Support System (ECLSS).

The WRS was activated during the STS-126 mission. However, after operating briefly, the Urine Processing Assembly (UPA) that begins the recycling process shut down. Fincke and shuttle Mission Specialist Don Pettit worked with designers from Marshall Space Flight Center in Huntsville, Ala., to troubleshoot the problem and restart the system. However, after Discovery departed, that part of the recycling system failed again. A new Distillation Assembly (DA) section of the UPA will be delivered by the STS-119 astronauts in an effort to restore the WRS to full functionality.

In the meantime, the WRS continues to process condensation from the station's atmosphere, reclaiming between one and three liters a day. That water eventually will be consumed by crew members, used for oxygen generation or used to fill the flush tank on the WHC.

The STS-126 crew returned several one-liter samples of recycled water for laboratory analysis. Preliminary analysis shows the quality of the water being produced by the WRS, whether recycled from urine while the UPA was working, or from condensation, has been well within water quality specifications for microbes and for the more than 350 different chemical compounds analyzed. More samples will be returned on STS-119 for additional analysis.

A Total Organic Carbon Analyzer (TOCA II) also was delivered and installed during STS-126, but experienced minor problems during Expedition 18 activation and checkout. The problems were in the gas-separator portion of the system and engineers developed a slightly different procedure that allows TOCA to be used for on-board analysis of water purity without any hardware changes. Engineers are continuing to conduct the planned 90-day checkout of the Water Recovery System, which is on schedule to be completed by the time the Expedition 19 crew arrives.

The Potable Water Dispenser (PWD) that provides the faucets used by the crew is still undergoing checkout. While the heated side is dispensing hot water that is free of bacteria, samples from the ambient, or normal, temperature side of the dispenser have contained higher than allowable levels. Full characterization of the bacteria present will be completed upon return of samples on the STS-119 flight. The Expedition 18 crew performed numerous flushes of the system using low levels of iodine, but this was insufficient to remove the bacteria. The STS-119 mission will deliver a kit to disinfect the PWD by flushing it with a concentrated iodine solution. The flushes, which are similar to those performed on earthbound water distribution systems, use iodine instead of chlorine to avoid corrosion in the space station's plumbing.

## Environmental Control and Life Support System

Earth's natural life support system supplies the air we breathe, the water we drink and other essential conditions. For people to live in space, however, these functions must be provided by artificial means.

The life support systems on the Mercury, Gemini and Apollo spacecraft in the 1960s were designed to be used once and discarded. Oxygen for breathing was provided from high pressure or cryogenic storage tanks. Carbon dioxide was removed from the air by lithium hydroxide in replaceable canisters. Contaminants in the air were removed by replaceable filters and activated charcoal integrated with the lithium hydroxide canisters. Water for the Mercury and Gemini missions was stored in tanks, while fuel cells on the Apollo spacecraft produced electricity and provided water as a byproduct. Urine and wastewater were collected and stored or vented overboard.

The space shuttle is a reusable vehicle, unlike those earlier spacecraft, and its life support system incorporates some advances. It still relies heavily on the use of consumables; however, limiting the time it can stay in space.

The space station includes further advances in life support technology and relies on a combination of expendable and limited regenerative life support technologies located in the U.S. Destiny lab module and the Russian Zvezda service module. Advances include the development of regenerable methods for supplying water, by recovering potable water from wastewater, and oxygen, by electrolysis of water.

Because it is expensive to continue launching fresh supplies of air, water and expendable life support equipment to the station and returning used equipment to Earth, these advances will help reduce costs.

By recycling urine and condensation collected from the atmosphere, the ECLSS will reduce the dependence on Earth resupply by cutting the amount of water and consumables needed to be launched by about 15,000 pounds per year.

The space station's ECLSS performs several functions:

- Provides oxygen for metabolic consumption
- Provides potable water for consumption, food preparation and hygiene uses
- Removes carbon dioxide from the cabin air
- Filters particulates and microorganisms from the cabin air
- Removes volatile organic trace gases from the cabin air
- Monitors and controls cabin air partial pressures of nitrogen, oxygen, carbon dioxide, methane, hydrogen and water vapor in the cabin air
- Maintains total cabin pressure
- Maintains cabin temperature and humidity levels
- Distributes cabin air between connected modules

## Providing Clean Water

The space station's Environmental Control and Life Support System includes two key components, the WRS and OGS, which are packaged into three refrigerator-sized racks in the station's U.S. lab.

The WRS provides clean water by reclaiming wastewater, including water from crew member urine, cabin humidity condensate and Extravehicular Activity (EVA) wastes. The recovered water must meet stringent purity standards before it can be used to support crew, spacewalking and payload activities.

A distillation process is used to recover water from urine. The process occurs within a rotating distillation assembly that compensates for the absence of gravity, aiding in the separation of liquids and gases in space. Once distilled, the water from the urine processor is combined with other wastewaters and delivered to the water processor for treatment.

The WRS consists of a Urine Processor Assembly (UPA) and a Water Processor Assembly (WPA). A low-pressure vacuum distillation process is used to recover water from urine. The entire process occurs within a rotating distillation assembly that compensates for the absence of gravity and aids in the separation of liquids and gases in space.

Water from the urine processor is combined with all other wastewaters and delivered to the water processor for treatment. The water processor removes free gas and solid materials such as hair and lint, before the water goes through a series of multifiltration beds for further purification. Any remaining organic contaminants and microorganisms are removed by a high-temperature catalytic reactor assembly.

The purity of water is checked by electrical conductivity sensors. The conductivity of water is increased by the presence of typical contaminants. Unacceptable water is reprocessed, and clean water is sent to a storage tank, ready for use by the crew.

Engineers at Marshall Space Flight Center, Huntsville, Ala., and at Hamilton Sundstrand Space Systems International Inc., Windsor Locks, Conn., led the design and development of the Water Recovery System.

The WRS is designed to recycle crew member urine and wastewater for reuse as clean water. By doing so, the system reduces by 15,000 pounds per year the net mass of water and consumables that would need to be delivered from Earth.

Each crew member uses about 3.5 liters (0.9 gallons) of water per day. About 2 liters (0.52 gallons) per day is provided by deliveries from Russian Progress resupply vehicles, ESA's Jules Verne Automatic Transfer Vehicle and the space shuttles. The remaining 1.5 liters (0.4 gallons) is recovered condensate from the Russian water processor. The two cargo vehicles carry water to the station in onboard supply tanks. The shuttle delivers water produced as a byproduct of the fuel cells that generate its electricity. The WRS will reduce the amount of water that needs to be delivered to the station for each crew member by 1.3 liters (0.34 gallons) a day, or about 65 percent. Over the course of a year, it will reduce water deliveries to the station for a six-person crew by 2,850 liters (743 gallons).

## Oxygen Generation System

The OGS produces oxygen for breathing air for the crew and laboratory animals, and for replacement of oxygen lost because of experiment use, airlock depressurization, module leakage and carbon dioxide venting. The system consists mainly of the Oxygen Generation Assembly (OGA) and a Power Supply Module.

The heart of the Oxygen Generation Assembly is the cell stack, which electrolyzes, or breaks apart, water provided by the WRS, yielding oxygen and hydrogen as byproducts. The oxygen is delivered to the cabin atmosphere and the hydrogen is vented overboard. The Power Supply Module provides the power needed by the OGA to electrolyze the water.

The OGS is designed to generate oxygen at a selectable rate and capable of operating both continuously and cyclically. It provides from 5 to 20 pounds of oxygen per day during continuous operation and a normal rate of 12 pounds of oxygen per day during cyclic operation.

The OGS will accommodate the testing of an experimental Carbon Dioxide Reduction Assembly. Once deployed, the reduction assembly will cause hydrogen produced by the OGA to react with carbon dioxide removed from the cabin atmosphere to produce water and methane. The water will be available for processing and reuse, further reducing the amount of water resupplied to the space station from the ground.

## Future

Ultimately, expendable life support equipment is not suitable for long-duration, crewed missions away from low Earth orbit because of the resupply requirements. On deep space missions in the future, such resupply will not be possible because of the distances involved, and it will not be possible to take along all of the water and air required for a voyage of months or years. Regenerative life support hardware, which can be used repeatedly to generate and recycle the life-sustaining elements required by human travelers, is essential for long-duration trips into space.

## HTV Summary

The H-II Transfer Vehicle (HTV), designed and being built in Japan, is an unmanned cargo-transfer spacecraft that will deliver supplies to the International Space Station.

The HTV will be launched from the Tanegashima Space Center in Japan aboard an H-IIB Launch Vehicle that is currently under development. When the HTV approaches to within close proximity of the space station, the station's robotic arm, the Space Station Remote Manipulator System, will grapple the HTV and berth it to the space station. The HTV will deliver to the station up to 6,000 kg (13,228 pounds) of supplies, including food, clothing and several types of experiment payloads. After the supplies are unloaded, the HTV then will be loaded with waste materials, including used payloads or used clothing. Afterward, the HTV will undock and depart from the station, and deorbit and re-enter the atmosphere. While the HTV is berthed to the orbiting complex, crew members will be able to enter and remove supplies from the HTV Pressurized Logistics Carrier.

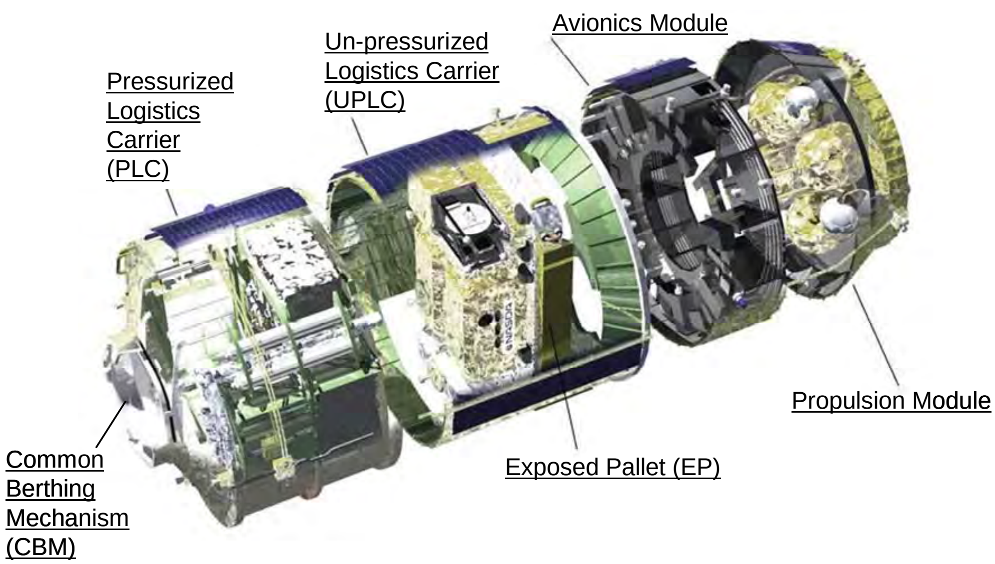
***Image of HTV during flight***

The HTV will be used for delivering supplies to the space station as is currently done with the Russian Progress cargo spacecraft, the U.S. space shuttle, and the Automated Transfer Vehicle developed and built by the European Space Agency. The HTV can carry both pressurized (for inside use) and unpressurized (for outside use) cargo. The launch of the HTV Technical Demonstration Vehicle, the initial flight vehicle, is scheduled during Japan's 2009 fiscal year.

**HTV Components**

The HTV consists of two logistic carriers, the Pressurized Logistics Carrier and the Unpressurized Logistics Carrier, which carries an Exposed Pallet, an Avionics Module and a Propulsion Module.

Proximity Communication System antennas and reflectors that enable interorbit communications between Kibo and the HTV are installed on Kibo and will be used when the HTV approaches the space station.




***HTV Configuration Diagram***

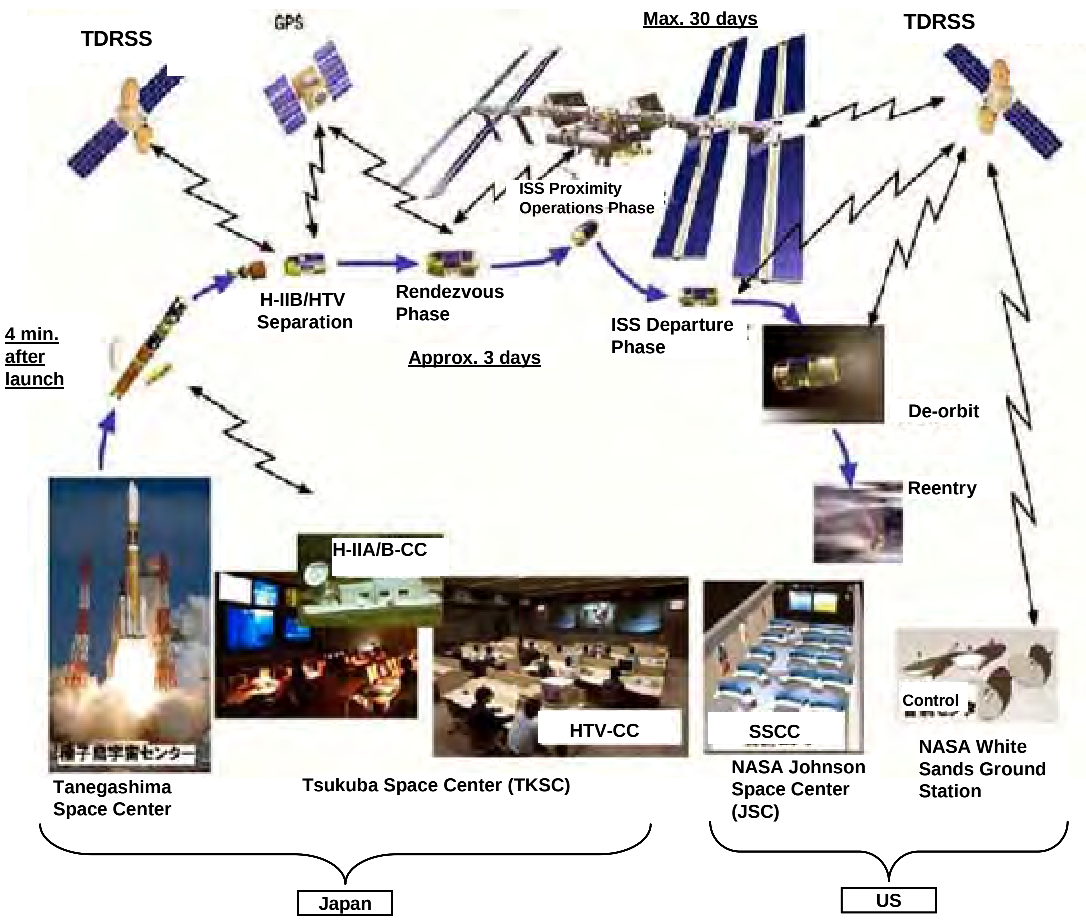
***HTV Specifications***

| Item | Specification |
|---|---|
| Length | 10m (including thrusters) |
| Diameter | 4.4m |
| Mass (weight) | 10,500kg (excluding cargo mass) |
| Cargo capacity (supplies) | 6,000kg<br>- Pressurized cargo: 4,500kg<br>- Unpressurized cargo: 1,500kg |
| Cargo capacity (waste) | 6,000kg |
| Target orbit to ISS | Altitude: 350km to 460km<br>Inclination: 51.6 degrees |
| Maximum mission duration | Solo flight: 100 hours<br>Stand-by (on-orbit): More than a week<br>Berthed with the ISS: Maximum 30 days |

## HTV Operations

The HTV will be operated in the following sequence.

1. Launch
2. Rendezvous with the International Space Station
3. Berthing with the space station
4. Operations while berthed with the station
5. Undock/Departure from the station/re-entry



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# International Space Station: Expedition 19/20 Science Overview

Expedition 19/20 includes operating 98 experiments in human research, technology development; observing the Earth; and performing educational activities and biological and physical sciences aboard the International Space Station. The experiments have been prioritized based on fundamental and applied research needs established by NASA and the international partners – the Canadian Space Agency (CSA), the European Space Agency (ESA), and the Japan Aerospace Exploration Agency (JAXA). Russia manages its experiments and requirements separately.

The scientific work of more than 400 scientists will be supported through U.S.-integrated experiments. The team of controllers and scientists on the ground will continue to plan, monitor and remotely operate experiments from control centers across the United States.

The controllers will staff the Payload Operations Center – the science command post for the space station – at NASA's Marshall Space Flight Center in Huntsville, Ala. Controllers work in three shifts around the clock, seven days a week in the Payload Operations Center, which links researchers around the world with their experiments and the station crew.

The Payload Operations Center also coordinates the payload activities of NASA's international partners. While the partners are responsible for the planning and operations of their space agencies' modules, NASA's Payload Operations Center is chartered to synchronize the payload activities among the partners and optimize the use of valuable in-orbit resources.

## Human Research and Countermeasures Development

Sampling and testing of crew members will be used to study changes in the body caused by living in microgravity. Continuing and new experiments include:

**Bisphosphonates as a Countermeasure to Space Flight Induced Bone Loss (Bisphosphonates)** will determine whether antiresorptive agents – those that help reduce bone loss on Earth – in conjunction with the routine in-flight exercise program, will protect station crew members from bone loss, which has been observed and documented on previous missions.

**Cardiac Atrophy and Diastolic Dysfunction During and After Long Duration Spaceflight: Functional Consequences for Orthostatic Intolerance, Exercise Capability and Risk for Cardiac Arrhythmias (Integrated Cardiovascular)** will determine how much cardiac atrophy, or a decrease in the size of the heart muscle, occurs during spaceflight. It will study how fast atrophy occurs and whether it causes problems with the heart's pumping or electrical function.

**Validation of Procedures for Monitoring Crew member Immune Function (Integrated Immune)** will assess the clinical risks resulting from the adverse effects of spaceflight on the human immune system. The study will validate a flight-compatible immune monitoring strategy by collecting and analyzing blood, urine and saliva samples from crew members before, during and after spaceflight to monitor changes in the immune system.

**Nutritional Status Assessment (Nutrition)** studies human physiological changes during long-duration spaceflight. Results will impact both the definition of nutritional requirements and development of food systems for future space exploration missions to the moon and beyond. This experiment also will help researchers understand the impact of countermeasures – exercise and pharmaceuticals – on nutritional status and nutrient requirements for astronauts.

**The National Aeronautics and Space Administration Biological Specimen Repository (Repository)** is a storage bank used to maintain biological specimens over extended periods of time and under well-controlled conditions. Samples from crew members on the station – including blood and urine – will be collected, processed and archived during the pre-flight, in-flight and post-flight phases of the missions. This investigation has been developed to archive biological samples for use as a resource for future spaceflight research.

**Sleep-Wake Actigraphy and Light Exposure during Spaceflight-Long (Sleep-Long)** examines the effects of spaceflight and ambient light exposure on the sleep-wake cycles of the crew members during long-duration stays on the space station. Results are vital to treating insomnia in space.

**A Comprehensive Characterization of Microorganisms and Allergens in Spacecraft (SWAB)** will comprehensively evaluate microbes aboard the space station, including pathogens – organisms that may cause disease. This study will allow an assessment of the risk of microbes to the crew and the spacecraft.

**Evaluation of Maximal Oxygen Uptake and Submaximal Estimates of $VO_2$max Before, During, and After Long Duration International Space Station Missions ($VO_2$max)** will document changes in aerobic capacity for crew members on long-duration missions, greater than 90 days. $VO_2$max is the standard measure of aerobic capacity, and is directly related to the physical working capacity of an individual. By understanding the changes in $VO_2$max in spaceflight, necessary adjustments can be made to exercise regimes for future crews that may help combat any negative effects.

## Technology Development

Many experiments are designed to help develop technologies, designs and materials for future spacecraft and exploration missions. These include:

**JPL Electronic Nose (ENose)** is a full-time, incident monitor designed to detect air contamination from spills and leaks inside the station. It is envisioned to be one part of a distributed system for automated monitoring and control of the breathing atmosphere in inhabited spacecraft in microgravity.

**Multi-User Droplet Combustion Apparatus – Flame Extinguishment Experiment (MCDA-FLEX)** will assess the effectiveness of fire suppressants in microgravity and quantify the effect of different atmospheres on fire suppression. This will provide definition and direction for large-scale fire suppression tests and selection of the fire suppressant for next-generation crew exploration vehicles.

**Materials on the International Space Station Experiment 6 A and B (MISSE-6A and 6B)** is a test bed for materials and coatings attached to the outside of the space station that are being evaluated for the effects of atomic oxygen, direct sunlight, radiation and extremes of heat and cold. This experiment allows the development and testing of new materials to better withstand the rigors of space environments. Results will provide a better understanding of the durability of various materials in space.

**Serial Network Flow Monitor (SNFM)** will study the function of the computer network aboard the station. This information will allow monitoring and improvement in the data transfer capabilities of in-orbit computer networks.

**Space-Dynamically Responding Ultrasonic Matrix System (SpaceDRUMS)** is a suite of hardware to facilitate containerless advanced materials science. Inside SpaceDRUMS, samples of experimental materials, such as porous ceramics, can be processed without ever touching a container wall. Results will help scientists on Earth determine methods to make better materials for use on Earth and in space.

**Synchronized Position Hold, Engage, Reorient, Experimental Satellites (SPHERES)** are bowling-ball-sized spherical satellites. They will be used inside the space station to test a set of well-defined instructions for spacecraft performing autonomous rendezvous and docking maneuvers. Three free-flying spheres will fly inside the station, performing flight formations. Each satellite is self-contained with power, propulsion, computers and navigation equipment. The results are important for satellite servicing, vehicle assembly and formation-flying spacecraft configurations.

**Vehicle Cabin Atmosphere Monitor (VCAM)** will test the air, water and surface of the station interior for contaminants. The station environment can be contaminated by off-gassing of vapors from items such as plastics and tapes, as well as bacteria and fungi. Results of monitoring the station will provide a new understanding of the closed environment that can be applied to future spacecraft.

## Biological Sciences in Microgravity

Plant growth experiments give insight into the effects of the space environment on living organisms. These experiments include:

**Transgenic Arabidopsis Gene Expression System (TAGES)** uses Arabidopsis thaliana, commonly known as thale cress, to determine how plants perceive stresses such as drought, inadequate light, or varying temperatures in space.

**Investigating the Structure of Paramagnetic Aggregates from Colloidal Emulsions – 2 (InSPACE-2)** will obtain data on magnetorheological fluids – fluids that change properties in response to magnetic fields – that can be used to improve or develop new brake systems for vehicles, and robotics.

**Validating Vegetable Production Unit (VPU) Plants, Protocols, Procedures and Requirements ($P^3R$) Using Currently Existing Flight Resources (Lada-VPU-$P^3R$)** is a study to advance the technology required for plant growth in microgravity and to research related food safety issues. It also investigates the non-nutritional value to the flight crew of developing plants in orbit.

## Education and Earth Observation

Many experiments aboard the space station continue to teach lessons about living and working in space. These experiments include:

**Agricultural Camera (AgCam)** takes frequent images, in visible and infrared light, of vegetated areas on Earth, such as farmland, rangeland, grasslands, forests and wetlands in the northern Great Plains and Rocky Mountain regions of the United States. Images will be delivered within two days directly to requesting farmers, ranchers, foresters, natural resource managers and tribal officials to help improve environmental stewardship.

**Crew Earth Observations (CEO)** takes advantage of the crew in space to observe and photograph natural and human-made changes on Earth. The photographs record the Earth's surface changes over time, along with dynamic events such as storms, floods, fires and volcanic eruptions. These images provide researchers on Earth with key data to better understand the planet.

**Earth Knowledge Acquired by Middle School Students (EarthKAM)**, an education experiment, allows middle school students to program a digital camera aboard the station to photograph a variety of geographical targets for study in the classroom. Photos are made available on the Web for viewing and study by participating schools around the world. Educators use the images for projects involving Earth science, geography, physics and technology.

**Education Payload Operations – Kit D (EPO – Kit D)** is part of NASA's continuing effort to use space as a unique educational tool for K-12 students. Everyday items, such as toys and tools, are given a new twist by combining them with the allure of the unusual space environment to produce educational materials that inspire interest in science, technology, engineering and mathematics.

**HICO and RAIDS Experiment Payload – Hyperspectral Imager for the Coastal Ocean (HREP-HICO)** will operate a visible and near-infrared (VNIR) Maritime Hyperspectral Imaging (MHSI) system, to detect, identify and quantify coastal geophysical features from the space station.

**HICO and RAIDS Experiment Payload – Remote Atmospheric and Ionospheric Detection System (HREP-RAIDS)** will provide atmospheric scientists with a complete description of the major constituents of the thermosphere, the fourth layer of the Earth's atmosphere where the space shuttle and space station orbit, and ionosphere, the uppermost layer of the Earth's atmosphere, and provide global electron density profiles at altitudes between 100 - 350 kilometers.

## Space Shuttle Experiments

Many other experiments are scheduled to be performed during upcoming space shuttle missions that are part of Expedition 19/20. These experiments include:

**Atmospheric Neutral Density Experiment – 2 (ANDE-2)** will measure the density and composition of the low Earth orbit atmosphere while tracking from the ground two microsatellites launched from the shuttle payload bay. The data will be used to better predict the movement of objects in orbit.

**Dual RF Astrodynamic GPS Orbital Navigator Satellite (DRAGONSat)** is designed to prove that autonomous rendezvous and docking of two spacecraft can be performed in low Earth orbit. The project also will gather flight data with a global positioning system receiver to demonstrate precision navigation.

**Maui Analysis of Upper Atmospheric Injections (MAUI)** observes the space shuttle engine exhaust plumes from the Maui Space Surveillance Site in Hawaii. The observations will occur when the shuttle fires its engines at night or twilight. A telescope and all-sky imagers will collect images and data while the shuttle flies over the Maui site. The images will be analyzed to better understand the interaction between the spacecraft plume and the upper atmosphere.

**National Lab Pathfinder – Vaccine – 4 and National Lab Pathfinder – Vaccine – 5 (NLP-Vaccine-4 and NLP-Vaccine-5)** is a suite of investigations serving as a pathfinder for the use of the space station as a National Laboratory after station assembly is complete. It contains several different pathogenic, or disease causing, organisms. This research is investigating the use of spaceflight to develop potential vaccines for the prevention of different infections caused by these pathogens on Earth and in microgravity.

**Shuttle Exhaust Ion Turbulence Experiments (SEITE)** will use space-based sensors to detect turbulence inferred from the radar observations from a previous Space Shuttle Orbital Maneuvering System (OMS) burn experiment using ground-based radar. The research will enhance detection, tracking and timely surveillance of high-interest objects in space.

**Spinal Elongation and its Effects on Seated Height in a Microgravity Environment (Spinal Elongation)** study will provide quantitative data as to the amount of change that occurs in the seated height due to spinal elongation in microgravity.

**Validation of Procedures for Monitoring Crew Member Immune Function – Short Duration Biological Investigation (Integrated Immune – SDBI)** will assess the clinical risks resulting from the adverse effects of spaceflight on the human immune system for space shuttle crew members. The study will validate a flight-compatible immune monitoring strategy by collecting and analyzing blood, urine and saliva samples from crew members before, during and after spaceflight to monitor changes in the immune system.

**Shuttle Ionospheric Modification with Pulsed Localized Exhaust Experiments (SIMPLEX)** will use ground-based radars to investigate plasma turbulence driven by rocket exhaust in the ionosphere – four layers of the Earth's upper atmosphere where space radiation can create an area that reflects radio signals. Results will help in the interpretation of spacecraft engine plumes when they are observed from Earth.

**Sleep-Wake Actigraphy and Light Exposure During Spaceflight – Short (Sleep-Short)** examines the effects of spaceflight on the sleep-wake cycles of the astronauts during space shuttle missions. Advancing state-of-the-art technology for monitoring, diagnosing and assessing treatment of sleep patterns is vital to treating sleep disorders on Earth and in space.

**Human Factors Assessment of Vibration Effects on Visual Performance During Launch (Visual Performance)** will determine visual performance limits during operational vibration and g-loads – the standard forces experienced by astronauts during space shuttle launches – on the space shuttle, specifically through the determination of minimum readable font size during ascent using planned Orion crew capsule display formats.

## Reserve Payloads

Several additional experiments are ready for operation, but designated as "reserve" and will be performed if crew time becomes available. They include:

**Binary Colloidal Alloy Test – 3 (BCAT-3)** investigates the long-term behavior of colloids – a system of fine particles suspended in a fluid – in a microgravity environment, where the effects of sedimentation and convection are removed. Results will help scientists develop fundamental physics concepts previously masked by the effects of gravity.

**Binodal Colloidal Aggregation Test – 4 (BCAT-4)** is part of the BCAT suite of experiments studying colloids – a system of fine particles suspended in a fluid. Results from this study may lead to new colloid materials with applications in the communications and computer industries for switches, displays and optical devices with properties that could rival those of lasers.

**Binary Colloidal Alloy Test – 5 (BCAT-5)** initially will photograph randomized colloidal samples to determine their resulting structure over time. Results will provide important data that is not available on Earth to guide our understanding of product shelf-life.

**Cardiovascular and Cerebrovascular Control on Return from ISS (CCISS)** studies the effects of long-duration spaceflight on crew members' heart functions and blood vessels that supply the brain. Learning more about the cardiovascular and cerebrovascular systems could lead to specific countermeasures that might better protect future space travelers.

**Education Payload Operations (EPO)** includes curriculum-based educational activities demonstrating basic principles of science, mathematics, technology, engineering and geography. These activities are videotaped and then used in classroom lectures.

**Lab-on-a-Chip Application Development-Portable Test System (LOCAD-PTS)** is a handheld device for rapid detection of biological and chemical substances aboard the space station. Astronauts will swab surfaces within the cabin, add swab material to the LOCAD-PTS, and within 15 minutes obtain results on a display screen. The study's purpose is to effectively provide an early warning system to crew members to protect their health and safety.

**Microgravity Acceleration Measurement System (MAMS) and Space Acceleration Measurement System – II (SAMS-II)** measure vibration and quasi-steady accelerations that result from vehicle control burns, docking and undocking activities. The two different equipment packages measure vibrations at different frequencies. These measurements help investigators characterize the vibrations and accelerations that may influence space station experiments.

**Vehicle Cabin Atmosphere Monitor (VCAM)** identifies gases that are present in small quantities in the space station breathing air that could be harmful to crew health. If successful, instruments like this could accompany crew members during long-duration exploration missions to the moon or Mars.

## Research Facilities

The space station is equipped with these state-of-the-art research facilities to support science investigations:

The **Combustion Integrated Rack (CIR)** is used to perform combustion experiments in microgravity. It is designed to be easily reconfigured in orbit to accommodate a wide variety of combustion experiments.

The **General Laboratory Active Cryogenic ISS Experiment Refrigerator (GLACIER)** will serve as an in-orbit cold stowage facility as well as carry frozen scientific samples to and from the station and Earth via the space shuttle. This facility is capable of thermally controlling the samples between 4°C (39.2°F) and minus 185°C (minus 301°F).

The **Human Research Facility-1(HRF-1)** is designed to house and support life sciences experiments. It includes equipment for lung function tests, ultrasound to image the heart and many other types of computers and medical equipment.

**Human Research Facility-2 (HRF-2)** provides an in-orbit laboratory that enables human life science researchers to study and evaluate the physiological, behavioral and chemical changes in astronauts induced by spaceflight.

**Minus Eighty-Degree Laboratory Freezer for ISS (MELFI)** provides refrigerated storage and fast-freezing of biological and life science samples. It can hold up to 300 liters of samples ranging in temperature from minus 80°C, minus 26°C, or 4°C throughout a mission.

**Expedite the Processing of Experiments to the Space Station (EXPRESS) Racks** are standard payload racks designed to provide experiments with utilities such as power, data, cooling, fluids and gases. The racks support payloads in disciplines including biology, chemistry, physics, ecology and medicines.

The racks stay in orbit, while experiments are changed as needed. EXPRESS Racks 2 and 3 are equipped with the **Active Rack Isolation System (ARIS)** for countering minute vibrations from crew movement or operating equipment that could disturb delicate experiments.

The **Microgravity Science Glovebox (MSG)** provides a safe environment for research with liquids, combustion and hazardous materials aboard the station. Without the glovebox, many types of hands-on investigations would be impossible or severely limited on the station.

The **European Modular Cultivation System (EMCS)** is a large incubator that provides control over the atmosphere, lighting and humidity of growth chambers used to study plant growth.

### On the Internet

For fact sheets, imagery and more on Expedition 19/20 experiments and payload operations, click on

**http://www.nasa.gov/mission_pages/station/science/index.html**

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# The Payload Operations Center

***From the Payload Operations Center at NASA's MSFC in Huntsville, Ala., scientists and engineers operate all the U.S. experiments 225 miles above Earth on the International Space Station. The best technology of the 21st century monitors and stores several billion bits of data from the space station, while saving NASA millions of dollars and serving a diverse community of research scientists around the globe.***

The Payload Operations Center, or POC, at NASA's Marshall Space Flight Center in Huntsville, Ala., is NASA's primary science command post for the International Space Station. Space station scientific research plays a vital role in NASA's roadmap for returning to the moon and exploring our solar system.

The space station accommodates dozens of experiments in fields as diverse as medicine, human life sciences, biotechnology, agriculture, manufacturing and Earth observation. Managing these science assets, as well as the time and space required to accommodate experiments and programs from a host of private, commercial, industry and government agencies nationwide, makes the job of coordinating space station research critical.

The Payload Operations Center continues the role Marshall has played in management and operation of NASA's in-orbit science research. In the 1970s, Marshall managed the science program for Skylab, the first American space station. Spacelab, the international science laboratory that the space shuttle carried to orbit more than a dozen times in the 1980s and

1990s, was the prototype for Marshall's space station science operations.

Today, the POC team is responsible for managing all U.S. science and research experiments aboard the station. The center also is home for coordination of the mission planning work, deliveries and retrieval of all U.S. science payloads, and payload training and payload safety programs for the station crew and all ground personnel.

State-of-the-art computers and communications equipment deliver around-the-clock reports between science outposts across the United States and POC systems controllers and science experts. Other computers stream information to and from the space station itself, linking the orbiting research facility with the science command post on Earth.

The payload operations team also synchronizes the payload time lines among international partners, ensuring the best use of valuable resources and crew time. NASA's partners are the Russian Space Agency, European Space Agency, Japan Aerospace and Exploration Agency and Canadian Space Agency.

The control centers of NASA's partners are:

- Center for Control of Spaceflights ("TsUP" in Russian) in Korolev, Russia;
- Space Station Integration and Promotion Center (SSIPC) in Tskuba, Japan; and
- Columbus Control Center (Col-CC) in Oberpfaffenhofen, Germany

Once launch schedules are finalized, the POC oversees delivery of experiments to the space station. Experiments are rotated in and out periodically as the shuttle or other launch vehicles make deliveries and return completed experiments and samples to Earth.

Housed in a two-story complex at Marshall, the systems controllers staff the POC around the clock in three shifts. During space station operations, center personnel routinely manage 10 to 40 or more experiments simultaneously.

The payload operations director leads the POC's main flight control team, known as the "cadre." The payload operations director approves all science plans in coordination with Mission Control at NASA's Johnson Space Center in Houston, the station crew and the international partner control centers. The payload communications manager, the voice of the POC, coordinates and manages real-time voice responses between the station crew conducting payload operations and the researchers whose science the crew is conducting. The operations controller oversees station science operations resources, such as tools and supplies, and assures support systems and procedures are ready to support planned activities. The data management coordinator is responsible for station video systems and high-rate data links to the POC. The payload rack officer monitors rack integrity, power and temperature control, and the proper working conditions of station experiments.

Additional support controllers routinely coordinate anomaly resolution and procedure changes and maintain configuration management of on-board stowed payload hardware.

***Orbiting 250 miles above the Earth, the space station crew works together with science experts at the POC at the MSFC and researchers around the world to perform cutting-edge science experiments in the unique microgravity environment of space. (NASA)***

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# Russian Research Objectives

### *Expedition 19/20*

| Category | Experiment Code | Experiment Name | Hardware Description | Research Objective | Unique Payload Constraints |
|---|---|---|---|---|---|
| Technology & Material Science | ТХН-7 | SVS (CBC) | “CBC” researching camera “Telescience” hardware from “ПК-3”<br>*Nominal hardware:*<br>“Klest” (“Crossbill”)<br>TV-system<br>Picture monitor (ВКУ) | Self-propagating high-temperature fusion in space | |
| Geophysical | ГФИ-1 | Relaksatsiya | “Fialka-MB-Kosmos” - Spectrozonal ultraviolet system<br>Spectrometer №2 (СПМ) <TBD><br>Video camera (ВК) <TBD><br>High sensitive images recorder | Study of chemiluminescent chemical reactions and atmospheric light phenomena that occur during high-velocity interaction between the exhaust products from spacecraft propulsion systems and the Earth atmosphere at orbital altitudes and during the entry of space vehicles into the Earth upper atmosphere | Using OCA |
| Geophysical | ГФИ-8 | Uragan | *Nominal hardware:*<br>Camera Nikon D2X<br>Camera Nikon D200<br>HDV Sony HVR-Z1<br>Laptop RSS2, RSK1 | Experimental verification of the ground and space-based system for predicting natural and man-made disasters, mitigating the damage caused, and facilitating recovery | Using OCA |
| Geophysical | ГФИ-12 | Impulse (Pulse) | Hardware “IPI-SM” containing | Ionospheric sounding by pulsed plasma sources | Unattended |
| Geophysical | ГФИ-16 | Vsplesk (Burst) | “Vsplesk” hardware<br>Mechanical adapter<br>Conversion board | Seismic effects monitoring. Researching high-energy particles streams in near-Earth space environment | Unattended |
| Biomedical | МБИ-12 | Sonokard | “Sonokard” set<br>“Sonokard” kit<br>“Sonokard-Data” kit<br>Laptop RSE-Med | Integrated study of physiological functions during sleep period throughout a long spaceflight. | |
| Biomedical | МБИ-15 | Pilot | Right Control Handle<br>Left Control Handle<br>Synchronizer Unit (БС)<br>ULTRABUOY-2000 Unit<br>“Neyrolab-M” set<br>*Nominal hardware:*<br>Laptop RSK1 | Researching for individual features of state psychophysiological regulation and crew members professional activities during long spaceflights. | Using OCA |
| Biomedical | МБИ-16 | Vzaimodeistvie (Interaction) | “Vzaimodeistvie” kit<br>*Nominal hardware:*<br>Laptop RSK1 with a set of accessories | Monitoring of the group crew activities under spaceflight conditions | |
| Biomedical | МБИ-18 | Dykhanie | “Dykhanie-1” set<br>“Dykhanie-1-Data” kit<br>*Nominal hardware:*<br>Laptop RSE-Med | Study of respiration regulation and biomechanics under spaceflight conditions | |

## *Expedition 19/20 (continued)*

| Category | Experiment Code | Experiment Name | Hardware Description | Research Objective | Unique Payload Constraints |
|---|---|---|---|---|---|
| Biomedical | МБИ-20 | Tipologia | "Tipologia" kit<br>"Tipologia-Data" kit<br>"Neyrolab-M" set with accessories<br>*Nominal hardware:*<br>Laptop RSK1 | Researching for typological features of the activities of the ISS crews as operators activities in long term spaceflight phases | |
| Biomedical | МБИ-21 | Pneumocard | "Pneumocard" set<br>"Pneumocard-КРМ" kit<br>"Pneumocard-Data" kit<br>*Nominal hardware:*<br>Laptop RSE-Med | Study of spaceflight factors impacts on vegetative regulation of blood circulation, respiration and contractile heart function during long spaceflights | |
| Biomedical | БИО-1 | Poligen | "Drozophila-2" kit | Detection of genotypic features (experimental object – Drozophila midge), determining individual characteristics of resistance to the long-duration flight factors | During Exp. 18, Exp. 19 crews rotation |
| Biomedical | БИО-2 | Biorisk | "Biorisk-KM" set<br>"Biorisk-MSV" containers<br>"Biorisk-MSN" kit | Study of spaceflight impact on microorganisms-substrates systems state related to space technique ecological safety and planetary quarantine problem | EVA |
| Biomedical | БИО-5 | Rasteniya | "Lada" greenhouse<br>Module of substratum research<br>*Nominal Hardware:*<br>Water container;<br>Sony DVCam;<br>Computer | Study of the spaceflight effect on the growth and development of higher plants | |
| Biomedical | БИО-8 | Plazmida | Hybridizers Recomb-K<br>Kit with tubes<br>*Nominal Hardware:*<br>"Kriogem-03" freezer | Investigation of microgravity effect on the rate of transfer and mobilization of bacteria plasmids | During Exp. 18, Exp. 19 crews rotation |
| Biomedical | РБО-3 | Matryeshka-R | Passive detectors unit<br>"Phantom" set<br>"Bubble-dosimeter" hardware "Lyulin-5" hardware<br>"Matryeshka" equipment (monoblock)<br>AST Spectrometer | Study of radiation environment dynamics along the station's Russian segment flight path and in station compartments, and dose accumulation in anthropomorphous phantom, located inside and outside the space station | |
| Study of Earth natural resources and ecological monitoring | ДЗЗ-12 | Rusalka | "Rusalka" monoblock<br>Nikon D2X(s) camera<br>Bracket for attachment to the window | Testing of the procedure to determine the carbon dioxide and methane content in the Earth atmosphere to understand a role of natural processes in human activity | |
| Study of Earth natural resources and ecological monitoring | ДЗЗ-13 | Seyener | *Nominal hardware:*<br>Camera Nikon D2X<br>Sony HVR-Z1J<br>Laptop RSK2 | Experimental methodses of the interaction of the crews to cosmic station with court Fishing in process of searching for and mastering commercial-productive region of the World ocean | |
| Biotechnology | БТХ-5 | Laktolen | "Bioekologiya" kit | Effect produced by spaceflight factors on Laktolen producing strain | |

## *Expedition 19/20 (continued)*

| Category | Experiment Code | Experiment Name | Hardware Description | Research Objective | Unique Payload Constraints |
|---|---|---|---|---|---|
| Biotechnology | БТХ-6 | ARIL | | Effect produced by SFFs on expression of strains producing interleukins 1α, 1β, "ARIL" | During Exp. 18, Exp. 19 crews rotation |
| Biotechnology | БТХ-7 | OChB | | Effect produced by SFFs on strain producing superoxidodismutase (SOD) | |
| Biotechnology | БТХ-8 | Biotrack | "Bioekologiya" kit | Study of space radiation heavy charged particles fluxes influence on genetic properties of bioactive substances cells-producers | |
| Biotechnology | БТХ-10 | Kon'yugatsiya (Conjugation) | "Rekomb-K" hardware "Kriogem-03M" freezer *Nominal Hardware:* "Kriogem-03" freezer | Working through the process of genetic material transmission using bacteria conjugation method | During Exp. 18, Exp. 19 crews rotation |
| Biotechnology | БТХ-11 | Biodegradatsiya | "Bioproby" kit | Assessment of the initial stages of biodegradation and biodeterioration of the surfaces of structural materials | |
| Biotechnology | БТХ-14 | Bioemulsiya (Bioemulsion) | "Biocont-T" thermo-vacuum container | Study and improvement of closed-type autonomous reactor for obtaining biomass of microorganisms and bioactive substance without additional ingredients input and metabolism products removal | During Exp. 18, Exp. 19 crews rotation |
| Biotechnology | БТХ-26 | Cascad (cascade) | Changeable bioreactor Thermostat with drive control unit with stand and power supply cable in cover | Study of various types cells cultivation processes | During Exp. 18, Exp. 19 crews rotation |
| Biotechnology | БТХ-27 | Astrovaktsina (astrovaccine) | "Bioecologia" kit | Cultivation of E.Coli-protein Caf1 producer in zero-g | During Exp. 18, Exp. 19 crews rotation |
| Biotechnology | БТХ-29 | Zhenshen'-2 (Ginseng-2) | "Bioecologia" case | Study of the possibility to increase the ginseng biological activity | |
| Biotechnology | БТХ-40 | BIF | "Bioecologia" kit | Study of effect produced by spaceflight factors on technological and biomedical characteristics of bifid bacteria | During Exp. 18, Exp. 19 crews rotation |
| Biotechnology | БТХ-41 | Bakteriofag | "Bioecologia" kit | Study of effect produced by spaceflight factors on bacteriophage | During Exp. 18, Exp. 19 crews rotation |
| Technical Studies | TEX-14 (SDTO 12002-R) | Vektor-T | *Nominal Hardware:* ISS RS СУДН sensors; ISS RS orbit radio tracking [PKO] system; Satellite navigation; equipment [ACH] system GPS/GLONASS satellite systems | Study of a high-precision system for space station motion prediction | Unattended |

## *Expedition 19/20 (continued)*

| Category | Experiment Code | Experiment Name | Hardware Description | Research Objective | Unique Payload Constraints |
|---|---|---|---|---|---|
| Technical Studies | TEX-15 (SDTO 13002-R) | Izgib | *Nominal Hardware:*<br>ISS RS onboard measurement system (СБИ) accelerometers;<br>ISS RS motion control and navigation system GIVUS (ГИВУС СУДН)<br>Nominal temperature-sensing device for measures inside “Progress” vehicle modules<br>“Dakon” hardware | Study of the relationship between the onboard systems operating modes and space station flight conditions | |
| Technical Studies | TEX-22 (SDTO 13001-R) | Identifikatsiya | *Nominal Hardware:*<br>ISS RS СБИ accelerometers | Identification of disturbance sources when the microgravity conditions on the space station are disrupted | Unattended |
| Technical Studies | TEX-44 | Sreda-ISS (Environment) | *Nominal Hardware:*<br>Movement Control System sensors;<br>orientation sensors;<br>magnetometers;<br>Russian and foreign accelerometers | Studying station characteristics as researching environment | Unattended |
| Technical Studies | TEX-50 | Contur (Sidebar) | “Rokviss” hardware<br>Universal Working Place УРМ-Д | Development of the methods of management through Internet robot-manipulator on the space station | Unattended |
| Complex Analysis. Effectiveness Estimation | КПТ-2 <TBD> | Bar | “Bar” hardware containing<br>- “Kelvin-video” remote IRthermometer<br>- “Piran-V” pyroendoscope<br>- “Iva-6A” thermogigrometer<br>- TTM-2 thermoanemometer – thermometer<br>- AU-01 ultrasound analyzer<br>- UT2-03 leak indicator | Testing of principles and methods for the space station leak area control, selection of the sensor design and configuration | |
| Complex Analysis. Effectiveness Estimation | КПТ-3 | Econ | “Econ” kit<br>*Nominal Hardware:*<br>Nikon D1X digital camera, Laptop RSK1 | Experimental researching of station's Russian segment resources estimating for ecological investigation of areas | |
| Complex Analysis. Effectiveness Estimation | КПТ-6 | Plazma-MKS (Plasma-ISS) | “Fialka-MB-Kosmos” – Spectrozonal ultraviolet system | Study of plasma environment on station's external surface by optical radiation characteristics | |
| Complex Analysis. Effectiveness Estimation | КПТ-12 | Expert | “Bar” hardware | Study of microdestruction processes in the station's habitation modules under the long-term manned flight conditions | |

## *Expedition 19/20 (concluded)*

| Category | Experiment Code | Experiment Name | Hardware Description | Research Objective | Unique Payload Constraints |
|---|---|---|---|---|---|
| Complex Analysis. Effectiveness Estimation | КПТ-21 (ТЕХ-20) | Plazmennyi Kristall (Plasma Crystal) | "PC-3 Plus" experimental unit<br>"PC-3 Plus" telescience<br>*Nominal hardware:*<br>"Klest" ("Crossbill") TV-system | Study of the plasma-dust crystals and fluids under microgravity | |
| Complex Analysis. Effectiveness Estimation | КПТ-13 | Plazma-Progres | Ground observation facilities | Study of reflection characteristics of spacecraft plasma environment with onboard engines activated | Unattended |
| Study of cosmic rays | ИКЛ-2В | BTN-Neutron | Detection Block<br>Electronic Equipment Block<br>Mechanical interface | Study of fast and thermal neutrons fluxes | Unattended |
| Space education | ОБР-1 | Physics-Education | "Faza" (Phase) hardware:<br>- stand-alone ventilation system<br>"Flying saucer" hardware:<br>- experimental vessel kit<br>- macro-photography tripod<br>- illuminator with cables and power unit | Scientific-educational demonstration of physical laws and phenomena in microgravity conditions:<br>- operation of basic physical motion laws in weightlessness including the effect of reactive and gyroscopic forces on a solid body of revolution;<br>- diffusion processes and the effect of the liquid surface tension, gas bubbles aggregation during the phase separation of gas-liquid fine-disperser medium | |
| Space education | ОБР-3 | MAI-75 | Digital photo and video equipment and amateur radio communication system available onboard the ISS RS for the subsequent downlinking of video image to the ground | Spacecraft and up-to-date technologies for personal communications | |
| Commercial | КНТ-36 | EXPOSE-R | "EXPOSE-R" monoblock<br>Accessories kit | Exposure of material samples in open space conditions to study the effect of ultraviolet radiation on them | |

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# European Space Agency Experiment Program

During the Expedition 19/20 mission on the International Space Station there will be a full European experiment program in a host of different scientific areas with many using the internal and external research facilities of the Columbus laboratory, which was attached to the station as part of the STS-122 shuttle flight in February 2008. The experiments will be carried out by ESA astronaut Frank De Winne, other members of the Expedition 19/20 crew and also by visiting members of Soyuz and shuttle flights. The experiments are funded from the European ELIPS Program with additional funding from the European Commission.

## Internal Experiments: Biology

### ARTEMISS

ARTEMISS stands for Arthrospira sp. Gene Expression and mathematical Modeling on cultures grown in the International Space Station.

The purpose of this experiment is to determine the effect of spaceflight conditions, including weightlessness and radiation on the algae Arthrospira sp. The form, structure and physiology of the algae will be examined along with a genetic study of the organism. This data is important for determining the reliability of using Arthrospira sp. in spacecraft biological life support systems. Parameters derived from the spaceflight experiment will be used for subsequent mathematical modeling of Arthrospira sp. growth under spaceflight conditions.

**Science Team:**
N. Leys (BE), G. Dussap (FR), A. Wilmotte (BE), R. Wattiez (BE), J. Kviderova (CS)

### Biolab Facility: WAICO

This is the second run of the WAICO experiment in the Biolab facility within the European Columbus Laboratory. WAICO, which is the short name for Waving and Coiling of Arabidopsis Roots at different g-levels, concerns the effect that gravity has on the spiralling motion (circumnutation) that occurs in plant roots. It is suspected that this spiralling mechanism is an internal mechanism in the plant, independent of the influence of gravity. Seedlings grown on the space station from Arabidopsis root samples will be fixed and analyzed on return to Earth. Not only does this kind of research help to increase our knowledge of such growth processes that can help to increase the efficiency of agricultural processes on Earth, it also provides the basis for research into agricultural processes in space for future longer-term missions to the moon and Mars.

**Science Team:**
G. Scherer (DE)

### Biolab Facility: YING

The Yeast In No Gravity (YING) experiment is the second to take place in the Biolab facility. It will study the influence of weightlessness on so-called Flo proteins which regulate flocculation (clumping together) and adhesion of cells. Both cell-surface interaction on solid media and cell-cell interaction in liquid media in yeast cells (Saccharomyces cerevisiae) will be investigated. Weightlessness may have a direct impact on the yeast cell physiology and, in the case of yeast cell cultivation in liquid media, and indirect effect due to altered culture fluid dynamics in weightlessness. The overall goal is to obtain a detailed insight into the importance of weightlessness on the formation of organized cell structures and on flo processes, which are of considerable interest for fundamental science, industry and the medical field.

**Science Team:**
R. Willaert (BE), F. Delvaux (BE),
J. Nielsen (DK), M. Reuss (DE), L. Wyns (BE)

## Colored Fungi in Space

The objective of this experiment is to determine the effect of weightlessness and cosmic radiation on the growth and survival of colored fungi species. The fungal species chosen for the experiments are important degraders of organic materials, so it is of interest to study the survival of these fungi as possible contaminants of interplanetary spacecraft. The Colored Fungi in Space experiment is funded as part of the European Commission SURE project.

**Science Team:**
D. Hasegan (RO), O. Maris (RO),
G. Mogildea (RO), M. Mogildea (RO)

## GENARA

The existence of gravity-regulated genes, whose genetic expression depends (at least) upon the mechanism of sensing gravity and the redistribution of hormones, will be addressed in this experiment. In genetically modified Arabidopsis plants, several bio-monitors will be analyzed to determine the distribution of the plant hormones IAA (a type of auxin) and ABA (Abscisic Acid) at the tissue level in weightlessness or in a 1-g centrifuge. The experiment will take place in the European Modular Cultivation System with four experiment containers held in weightlessness and four held at 1g levels.

**Science Team:**
E. Carnero-Diaz (FR), G.Perbal (FR),
R. Ranjeva (FR), A. Graziana (FR),
M. Pages (ES), A. Goday (ES)

## Sample

This experiment investigates what kind of microbial species are to be found on board the International Space Station and how these adapt to conditions of spaceflight. The subject will take samples in certain areas of the space station and from their own body. The samples will be taken at places by rubbing swab sticks over surfaces, which are susceptible to having bacteria including switches, keyboards and personal hygiene equipment. In general this study is also helpful in providing further insight into the effect that spaceflight has on genetic modification.

**Science Team**
H.J.M. Harmsen (NL), G.W. Welling, (NL),
J. Krooneman (NL), L. van den Bergh (NL)

## Kubik Experiments

The following biology experiments will be carried out using a European incubator called Kubik currently on the space station. The samples for the experiments will be flown to the space station with the Expedition 19 crew on Soyuz 18S, with all samples being returned with the Expedition 18 crew on Soyuz 17S some 10 days later. As well as providing a thermally-controlled environment, an incubator will be fitted with a centrifuge, which provides the ability to run 1g control experiments while in orbit. The two experiments were originally part of the Bio-4 experiment package flown to the space station on flight 17S last year, but were rescheduled to the 18S flight. The two experiments are:

**Gravigen** – This experiment will investigate the effect of weightlessness on gene expression in plants (*Brassica napus).* It will help to identify genes whose expression is altered either by gravity or only by hyper- or microgravity. The results of this experiment will help us understand how gravity is perceived in plants and how this morphological information is transferred within plants at a genetic level. Polca and Gravigen are complementary studies, using the same conditions and biological material but analyzing different aspects of the gravi-response. This experiment will take place at a temperature of 22°C (71.6°F).

**Science Team:**
A. Graziana (FR) et al.

Polca – Polca will investigate the effect of weightlessness on the distribution of calcium in the statocytes of Rapeseed roots (Brassica napus). Statocytes are gravity-sensing cells in plant root tips, which contain calcium particles used within gravity-sensing process. Polca and Gravigen are complementary studies, using the same conditions and biological material but analyzing different aspects of the gravi-response. This experiment will take place at a temperature of 22°C (71.6°F).

**Science Team:**
V. Legué (FR) et al.

## Internal Experiments: Human Physiology

### 3D-Space

This physiology study investigates the effects of weightlessness on the mental representation of visual information during and after spaceflight. Accurate perception is a prerequisite for spatial orientation and reliable performance of tasks in space. The experiment has different elements including investigations of perception of depth and distance carried out using a virtual reality headset and standard psychophysics tests. Runs of the experiment have already been undertaken during Expedition 17 and 18, and are scheduled to continue with a target total of 10 Expedition crew members as test subjects.

**Science Team:**
G. Clement (FR), C.E. Lathan (US)

### Card

It has been observed that exposure to weightlessness increases cardiac output and lowers blood pressure (caused by dilated arteries) in the face of increased activity in the sympathetic nervous system (which normally constricts arteries). The Card experiment will examine these effects in order to provide a thorough picture of how the circulatory system changes during a prolonged stay in weightlessness. The experiment will consist of tests taken during a 24-hour period preflight, during the second half of the mission increment and post-flight. This will include: two blood samples; 24-hour urine samples; hourly blood pressure measurements; and cardiac output measurements with rebreathing every four hours except during sleep using the ESA/NASA Pulmonary Function System. The blood and urine samples will be examined for hormonal activity and electrolyte levels.

**Science Team:**
P. Norsk (DK), N.J. Christensen (DK),
B. Pump (DK), A. Gabrielsen (DK),
J.G. Nielsen (DK), C. Drummer (DE),
M. Kentsch (DE), N. Gadsboll (DK)

### Immuno

The aim of this experiment is to determine changes in hormone production and immune response during and after a space station mission. Cellular energy metabolism and cell signalling are focused on, to achieve additional information in the underlying processes and provide a better insight how these processes are dependent on the cellular level of signal processing. This experiment has already been carried out with four space station crew members as test subjects and another six are needed to conclude the experiment series.

**Science Team**
A. Chouker (DE), F. Christ (DE),
M. Thiel (DE), I. Kaufmann (DE),
B. Morukov (RU)

### MOP

When entering weightlessness, astronauts suffer from a phenomenon called space motion sickness, which has symptoms comparable to seasickness. This disturbance in the body's orientation and balance is similar to the disturbances experienced by subjects who have undergone rotation in a human centrifuge having experienced two to three times Earth's gravity for up to several hours. This experiment aims to obtain an insight into this process and could help in developing countermeasures to space motion sickness.

**Science Team:**
E. Groen (NL), J. Bos (NL), S. Nooij (NL),
W. Bles (NL), R. Simons (NL),
T. Meeuwsen (NL)

### Muscle

The deep muscle corset plays an important role in posture when in the upright position. It is thought that this deep muscle corset atrophies during spaceflight leading to strain and hence pain in certain ligaments, in particular the iliolumbar region in the back. The objective of this experiment is to assess the occurrence and characteristics of back pain. The results will be correlated to data related to back pain and atrophy obtained in ground-based studies.

**Science Team:**
A. Pool-Goudzwaard (NL),
C. Richardson (AU), J. Hides (AU),
L. Danneels (BE)

### Neurospat

This is the very first experiment to use the Columbus laboratory's European Physiology Modules Facility (MEEMM). Neurospat is actually a combination of two experiments: Neurocog-2 and Prespat.

**Neurocog-2:** In this project the purpose is to study brain activity that underlies cognitive processes involved in four different tasks that humans and astronauts may encounter on a daily basis: visuo-motor tracking; perception of self-orientation; 3D navigation; and the discrimination of the orientation of objects. These tasks are designed to produce changed responses of the sensorimotor system, responsible for the body's coordination and stability, in the presence or absence of gravity. The involvement of five cognitive processes will be examined: perception, attention, memory, decision and action. The roles played by gravity on these neural processes will be analyzed by different methods such as EEG during virtual reality stimulation.

**Science Team:**
G. Cheron (BE), C. Desadeleer (BE),
A. Cebolla (BE), A. Berthoz (FR),
A. Bengoetxea (BE)

**Prespat:** This experiment will use physiological and behavioral measures to assess changes in general activation, prefrontal brain function and perceptual reorganization. Different measurements will be taken during a spatial orientation task using such devices as an EEG. Novel visual stimuli also will be introduced, which are not task relevant to help make an electrophysiological assessment of novelty processing. The Prespat experiment is funded as part of the European Commission SURE project.

**Science Team:**
L. Balazs (HU), I. Czigler (HU),
G. Karmos (HU), M. Molnar (HU),
E. Nagy (HU), J. Achimowicz (PL)

### PADIAC

The PAthway DIfferent ACtivators experiment is a study of white blood cells (T-lymphocytes) in weightlessness. It will carry out a genetic analysis of T-cell activation by the CD28 molecule. Weightlessness alters the response of the immune system. The goals of this project are to determine different pathways for T-cell activation in space. This will improve the knowledge of the immune system and allow validation of control of T-cell activation. The experiment will make use of one of the European Kubik Incubators already on the station.

**Science Team:**
I. Walther (CH), M. Hughes-Fulford (US),
P. Pippia (IT), A. Cogoli (CH)

### Portable Pulmonary Function System

The Portable Pulmonary Function System is a new autonomous multi-user facility supporting a broad range of human physiological research experiments under weightless condition in the areas of respiratory, cardiovascular and metabolic physiology. The Portable Pulmonary Function System is an evolution to the existing Pulmonary Function System, (which is a joint ESA/NASA collaboration in the field of respiratory physiology instrumentation) currently on the space station. The Portable Pulmonary Function System will be utilized for undertaking the following experiments during Expedition 19/20:

**EKE:** The preservation of astronauts' aerobic capacity is a major goal of exercise countermeasures during space missions. A widely used measurement for endurance capacity is the maximal volume of oxygen used during exhaustive exercise, otherwise known as $VO_2$ max. A potential alternative method that will at least allow the reduction in the frequency of such tests is to determine the rate of changes in pulmonary oxygen uptake ($VO_2$) and heart rate responses during changes in workload.

Specific goals are the development of a diagnostic tool for the assessment of endurance capacity from oxygen uptake and heart rate in response to changes in exercise intensity and the development of a physiological model to explore the transport of oxygen from the lungs to muscle cells.

The EKE experiment will make use of the new Portable Pulmonary Function System.

**Science Team:**
U. Hoffman (DE), S. Fasoulas (DE),
D. Essfeld (DE), T. Drager (DE)

**Thermolab:** It is hypothesized that heat balance, thermo-regulation and circadian temperature rhythms are altered in humans during long-term spaceflights because of: changes in the natural convective heat transfer from the body surface to the environment; fluid shifts along the body axis from peripheral to central parts; changes in the cardiovascular and autonomous nervous systems; and changes of metabolism and body composition. Since these factors are particularly cross-linked with each other in view of thermoregulation, an integrative study of the topic under weightless conditions is necessary. This experiment will investigate thermoregulatory and cardiovascular adaptations during rest and exercise in the course of long-term exposure to weightlessness. The experiment utilizes the ESA-developed Portable Pulmonary Function System.

**Science Team:**
H.C. Gunga (DE), P. Arbeille (FR),
K. Kirsch (DE), E. Koralewski (DE),
J. Cornier (DE), H.V. Heyer (DE),
P. Hofmann (DE), J. Koch (DE),
F. Sattler (DE)

## Solo

The Solo experiment is carrying out research into salt retention in space and related human physiology effects. It is a continuation of extensive research into the mechanisms of fluid and salt retention in the body during bed rest and spaceflights and subsequent effect on bone metabolism. The astronaut subjects will participate in two study phases, six days each. Subjects follow a diet of constant either low or normal sodium intake, fairly high fluid consumption and isocaloric nutrition. This metabolically controlled study will make use of the European Physiology Modules Facility and Human Research Facility capabilities.

**Science Team:**
M. Heer (DE), N. Kamps (DE),
F. Baisch (DE), P. Norsk (DK)

## Ground Experiments: Baseline Data Collection

The following experiments are ground-based experiments, i.e., the experiment procedures will take place before and after the actual mission. A majority are continuations of experiments in order to increase the statistical significance of the results produced:

**EDOS:** Early Detection of Osteoporosis in Space (EDOS) is a study into the mechanisms underlying the reduction in bone mass, which occurs in astronauts in weightlessness. The EDOS experiment will evaluate the structure of weight- and non-weight-bearing bones of cosmonauts/astronauts pre- and post-flight using the method of computed tomography (pQCT) together with an analysis of bone biochemical markers in blood samples.

**Science Team:**

C. Alexandre (FR), L. Braak (FR),
L. Vico (FR), P. Ruegsegger (CH),
M. Heer (DE)

**Otolith:** The working of our balance system and our eyes are strongly interconnected and understanding their adaptation to weightlessness is important for maintaining an astronaut's capacity for carrying out tasks in space. The otolith organs in the inner ear play an important role in our balance system as detectors of vertical and horizontal acceleration. This experiment will make an assessment of otolith function before and after short-term spaceflight. This includes an assessment of otolith-ocular response to determine neural pathway communication between the otoliths and the Central Nervous System; an indication of function of the saccule, which transmits neural impulses of head movements to the brain; and evaluating the symmetry of information generated by the otoliths using an estimation of the astronaut's subjective visual vertical.

**Science Team:**
A. Clarke (DE), S. Wood (US), F. Wuyts (BE)

**Skin Properties:** Skin Properties is a human physiology experiment, which aims at characterizing aging of human skin (specifically: hydration grade, transepidermal water loss, elasticity, skin surface video imaging) in weightlessness and inside the International Space Station during a long-duration mission. With regard to already known effects on skin of a long-duration stay on the space station and the physiological effects of weightlessness, the investigators will test the applicability of the space environment as a model of the aging skin. The scientists will perform non-invasive medical measurements on selected astronauts, before and after their space missions. The Skin Properties experiment is funded as part of the European Commission SURE project.

**Science Team:**
T. Rodic, C3M (SI)

**Spin:** This experiment is a comparison between preflight and post-flight testing of astronaut subjects using a centrifuge and a standardized tilt test. Orthostatic tolerance, i.e., the ability to maintain an upright posture (without fainting) will be correlated with measures of otolith-ocular function, i.e., the body's mechanism linking the inner ear with the eyes that deals with maintaining balance.

**Science Team:**
F. Wuyts (BE), S. Moore (US),
H. MacDougall (AU), G. Clement (FR),
B. Cohen (US), N. Pattyn (BE),
A. Diedrich (US)

**ZAG:** ZAG, which stands for Z-axis Aligned Gravito-inertial force, is an investigation into the effect that weightlessness has on an astronaut's perception of motion and tilt as well as his level of performance before and immediately after spaceflight. Different tests will take place pre- and post-flight including an analysis of the astronaut's motion perception and eye movements while using a track-and-tilt chair. It also will be evaluated whether a tactile vest improves perception and performance during these tests.

**Science Team:**
G. Clement (FR), S. Wood (US),
M.F. Reschke (US), P. Denise (FR)

# Internal Experiments: Fluid Science

## Fluid Science Laboratory: Geoflow

Geoflow was the first experiment to take place within the Fluid Science Laboratory inside the European Columbus Laboratory, its first runs starting in August during Expedition 17. The experiment will continue to investigate the flow of an incompressible viscous fluid (silicon oil) held between two concentric spheres rotating about a common axis. A temperature gradient is maintained from the inside to the outside sphere as is an electrical field. This geometrical configuration can be seen as a representation of a planet, with the electric field simulating its gravitational field. This research is of importance in such areas as flow in the atmosphere, the oceans and in the liquid nucleus of planets on a global scale.

**Science Team:**
Ch. Egbers (DE), P. Chossat (FR),
F. Feudel (DE), Ph. Beltrame (DE),
I. Mutabazi (FR), L. Tuckerman (FR),
R. Hollerbach (UK)

## Foam Stability

The project aims at the study of aqueous and non-aqueous foams in a weightless environment. The behavior of foams in weightlessness and on Earth are very different, because the process of drainage is absent under weightless conditions. The effect/ enhancement of the foamability of liquid solutions without this drainage effect of gravity is investigated. Other fundamental questions addressed are: How long can those foams be stable? What is the role of solid particles in the liquid in water foam stabilization? Is it possible to create very “wet” foams in weightlessness?

Part of the experiment consists of a session to be compared with students in Europe who will perform the same experiment on the ground.

**Science Team:**
N. Vandewalle (BE), H. Caps (BE),
D. Langevin (FR), D.Weaire (IE),
M. Adler (FR) et al.

# Microgravity Science Glovebox – SODI

DSC and IVIDIL are two of the three SODI experiments, which also includes the Colloid experiment, which will take place during Expedition 21.

## DSC

The "Diffusion and Soret Coefficient Measurements for Improvement of Oil Recovery" experiment consists of three stages: 1) The determination of diffusion data requirements for petroleum reservoir models; 2) The simultaneous measurement of the Soret diffusion coefficients in binary and in tertiary systems; 3) The refinement of a multi-component transport model applied to petroleum reservoir evaluation. This experiment will provide information, which can be used in the more efficient extraction of oil resources.

**Science Team:**
S. Van Vaerenbergh (BE), J.C. Legros (BE),
J.P. Caltagirone (FR), J.L. Daridon (F),
Z. Zaghir (CND), A. Shapiro (DK)

## IVIDIL

The Influence of Vibrations on Diffusion in Liquids (IVIDIL) experiment will investigate the effects of vibrations on liquid diffusion. On the space station, there are residual vibrations (g-jitter). Although they seem to have a major impact on the measurement of the diffusion coefficient, very few studies have been carried out on this topic. Hence, the researchers plan to characterize the spectral influence of g-jitter. The objective of the experiment is to increase the understanding of the kinetic mechanisms influencing diffusion effects in the presence of vibrations.

**Science Team:**
J.C. Legros (BE), V. Shevtsova (BE),
B. Roux (FR), D. Lyubimov (RU),
T. Lyubimova (RU), S. van Vaerenbergh (BE),
Z. Saghir (CA)

# Internal Experiments: Material Science

## Material Science Laboratory – CETSOL & MICAST

CETSOL and MICAST will be the first ESA experiments to take place in the European-developed Materials Science Laboratory, which is scheduled to be transported to the space station on shuttle flight STS-128. These two complementary projects will carry out research into the formation of microstructures during the solidification of metallic alloys.

The goal of MICAST is to study the formation of microstructures during casting of technical alloys. In space, buoyancy convection is eliminated and the dendritic solidification of the alloys can be quantitatively studied under purely diffusive conditions. Controlled convection can also be realized by applying rotating magnetic fields to the conducting metallic melt.

The objective of CETSOL is then to study the transition from columnar growth – that is a front of dendrites developing into the melt as studied in MICAST – to equiaxed growth that occurs when crystals start to nucleate in the melt and grow independently.

The results obtained with the joined experimental program in space will permit to validate numerical simulations. These will in turn serve to optimize industrial casting processes.

**Science Team CETSOL:**
A. Gandin (FR), B. Billia (FR),
G. Zimmermann (DE), Y. Fautrelle (FR),
D. Browne (IE), D. Poirier (US)

**Science Team MICAST:**
L. Ratke (DE), G. Mueller (DE),
Y. Fautrelle (FR), A. Roosz (HU),
G. Zimmermann (DE), J. Lacaze (FR),
S. Dost (CA), D. Poirier (US)

## European Drawer Rack: Protein Crystallization Diagnostics Facility

The first subrack payload configuration of the European Drawer Rack in the Columbus laboratory includes the Protein Crystallization Diagnostics Facility, which will tackle the problems of protein crystallization in space. The aim of this project is to understand to what extent various transport-related phenomena contribute to the formation of defects and imperfections in biomolecular crystals. The expected results from experiments in weightlessness will help to identify the growth conditions and stages that are responsible for these defects. This will hold benefits in various industrial applications.

**Science Team:**
F. Otalora (E), D. Maes (B), S. Weinkauf (D),
E. Weckert (D), A. Chernov (USA),
J. Martial (B), G. Nicolis (B), F. Dubois (B)

# Internal Experiments: Radiation Dosimetry

## DOSIS (See also DOBIES)

The Dose Distribution inside the International Space Station (DOSIS) experiment will determine the nature and distribution of the radiation field inside the European Columbus laboratory. Measurements of energy, charge and LET spectra of heavy ions will be carried out using different active and passive detectors. The passive dosimeters will be distributed over 10 different locations for taking measurements, so-called area dosimetry. This experiment also makes additional use of information from the DOBIES experiment.

**Science Team:**
G. Reitz (DE) et al.

## DOBIES (See also DOSIS)

The aim of Dosimetry for Biological Experiments in Space (DOBIES) is to develop a standard method to measure the radiation dosage experienced by biological samples in specific areas of the station using a combination of different dosimetric techniques. The areas of interest are the Columbus laboratory and specifically the European Physiology Modules facility, and also in the EXPOSE-E and EXPOSE-R payloads (see EuTEF and EXPOSE-R respectively). Some of the measurements attained in the DOBIES experiment will contribute to the area dosimetry measurements in the DOSIS experiment.

**Science Team:**
F. Vanhavere (BE) et al.

## Matroshka

The ESA Matroshka facility has been an ongoing experiment on the station since February 2004, having been located on the external surface of the station and currently inside the station, with the aim of studying radiation levels experienced by astronauts. It consists of a human shape (head and torso) called the Phantom equipped with several active and passive radiation dosimeters. It is currently foreseen that the Phantom will be located inside the Japanese Kibo laboratory, equipped with a set of new passive dosimeters to take measurements for one year.

**Science Team:**
G. Reitz (DE), R. Beaujean (DE),
W. Heinrich (DE), M. Luszik-Bhadra (DE),
M. Scherkenbach (DE), P. Olko (PL),
P. Bilski (PL), S. Derne (HU), J. Palvalvi (HU),
E. Stassinopoulos (US), J. Miller (US),
C. Zeitlin (US), F. Cucinotta (US),
V. Petrov (RU)

## Experiments: Technology Demonstrations

### ERB-2 Life and Work on the International Space Station

This activity will utilize the first digital high-definition stereo camera, the Erasmus Recording Binocular (ERB) 2, to be flown on the station. Footage will be used to produce narrated video material for immediate and later use for promotional and educational purposes. One of the major objectives is to record 3D footage of different station elements to allow for an accurate 3D mapping of the interior of the station. The camera, a follow-up of the precursor ERB 1 in 2006, is capable of downlinking live footage in real time and recorded footage. This activity will take place during Expedition 20, when various events involving ground-based audiences are planned.

**Project Team:**
ESA Erasmus Center (ESA, NL)

### GTS-2 (Global Transmission Service)

The Global Transmission Services (GTS) Experiment is continuously operating on the Russian segment of the station since the year 2000, with its second generation active since the summer of 2007. This experiment is testing the receiving conditions of a time and data signal for dedicated receivers on the ground. The time signal distributed by the GTS has special coding to allow the receiver to determine the local time anywhere on the Earth without user intervention. The main scientific objectives of the experiment are to verify under real space operation conditions: the performance and accuracy of a time signal transmitted to the Earth's surface from low Earth orbit; the signal quality and data rates achieved on the ground; measurement of disturbing effects such as Doppler shifts, multi-path reflections, shadowing and elevation impacts. Following a short period of inactivity while awaiting prolongation of its operational agreement, GTS-2 was reactivated on Jan. 15, 2009. The ground control station in Stuttgart, Germany, is in continuous contact with the Russian Mission Control Center for GTS-2 operations.

**Project Team:**
F. Huber (DE)

# Internal Experiments: Education Activities

## Lesson-2 for secondary level classes (Take your classroom into school)

This activity will include a live link to secondary school students to give them an appreciation of the conditions of free fall through two simple, curriculum relevant demonstrations by using a stand-alone kit. The first demonstration is about mass measurement ('Do objects have weight in space?') and the second one about capillarity ('Exploring capillarity'). A T-shirt with a visual graphic element designed by children will be worn by the ESA astronaut during the live link recording. The recording of the demonstration will be used to produce ESA multimedia educational material.

**Project Team:**
ESA Human Spaceflight Coordination Office (ESA, NL)

## LES-3: Lesson from Space

An overview lecture will be given by Frank De Winne about life on the station including demonstrations of various water properties. One live link from the station to primary school students will take place. This will be broadcast to the Brussels planetarium with further distribution to various interested schools. The recording of the demonstration will be used to produce ESA multimedia educational material for upper primary school teachers and their students aged 10-12.

**Project Team:**
ESA Human Spaceflight Coordination Office (ESA, NL)

## External Experiments: Astrophysics/Technology/ Exobiology/Earth Observation

### Solar

The Solar facility, which has been on the External Payload Facility of Columbus since February 2008, has been studying the sun with unprecedented accuracy across most of its spectral range. This study is currently scheduled to last for two years. Solar is expected to contribute to the knowledge of the interaction between the solar energy flux and the Earth's atmosphere chemistry and climatology. This will be important for Earth observation predictions. The payload consists of three instruments complementing each other, which are:

**SOL-ACES**

The goal of the Solar Auto-Calibrating Extreme UV-Spectrometer (SOL-ACES) is to measure the solar spectral irradiance of the full disk from 17 to 220 nm at 0.5 to 2 nm spectral resolution. By an auto-calibration capability, it gains long-term spectral data with a high absolute resolution. In its center, it contains 4 Extreme Ultra-Violet spectrometers.

**Science Team:**
G. Schmidtke (DE)

**SOLSPEC**

SOLSPEC (SOLar SPECctral irradiance measurements) measures the solar spectrum irradiance from 180 nm to 3000 nm. The aims of this investigation are the study of solar variability at short and long term and the achievement of absolute measurements (2% in UV and 1% above). The SOLSPEC instrument was fully refurbished and improved with respect to the experience gained in the previous missions (Spacelab-1, Atlas-1, Atlas-2, Atlas-3, Eureca).

**Science Team:**
M.G. Thuillier (FR)

**SOVIM**

The Solar Variability and Irradiance Monitor (SOVIM) is a re-flight of the SOVA experiment on board Eureca-1. The investigation has been studying the irradiance of the sun, with high precision and high stability. The total irradiance is being observed with active cavity radiometers and the spectral irradiance measurement is being carried out by one type of sun-photometer.

**Science Team:**
C. Frohlich (CH)

### EuTEF

The European Technology Exposure Facility (EuTEF) has also been located on the External Payload Facility of Columbus since February 2008. Along with Solar, it is one of the first two external facilities attached outside the Columbus laboratory. EuTEF houses the following experiments requiring either exposure to the open space environment or a housing on the external surface of the space station:

**DEBIE-2**

DEBIE, which stands for 'DEBris In orbit Evaluator', is a standard in-situ space debris and micro-meteoroid monitoring instrument which requires low resources from the spacecraft. It measures sub-mm sized particles and has three sensors facing in different directions. The scientific results from several DEBIE instruments on board different spacecraft will be compiled into a single database for ease of comparison.

**Science Team:**
G. Drolshagen – ESA

**Dostel**

Dostel (DOSimetric radiation TELescope) is a small radiation telescope that is measuring the radiation environment outside the station.

**Science Team:**
G. Reitz – DLR (DE)

**EXPOSE-E**

EXPOSE-E is a subsection of EuTEF and consists of five individual exobiology experiments:

- Life
  This experiment tests the limits of survival of Lichens, Fungi and symbionts.

  **Science Team:**
  S. Onofri (IT), L. Zucconi (IT),
  L. Selbmann (DE), S. Ott (DE),
  J.P. de Vera (ES), R. de la Torre (ES)

- Adapt
  This experiment concerns the molecular adaptation strategies of micro-organisms to different space and planetary UV climate conditions.

  **Science Team:**
  P. Rettberg (DE), C. Cockell (UK),
  E. Rabbow (DE), T. Douki (FR),
  J. Cadet (FR), C. Panitz (DE),
  R. Moeller (DE), G. Horneck (DE),
  H. Stan-Lotter (AT)

- PROCESS
  The main goal of the PROCESS (PRebiotic Organic ChEmistry on Space Station) experiment is to improve our knowledge of the chemical nature and evolution of organic molecules involved in extraterrestrial environments.

  **Science Team:**
  H. Cottin (FR), P. Coll (FR), D. Coscia (FR),
  A. Brack (FR), F. Raulin (FR)

- Protect
  The aim of this experiment is to investigate the resistance of spores, attached to the outer surface of spacecraft, to the open space environment. Three aspects of resistance are of importance: the degree of resistance, the types of damage sustained and the spores repair mechanisms.

  **Science Team:**
  G. Horneck (DE), J. Cadet (FR),
  T. Douki (FR), R. Mancinelli (FR),
  R. Moeller (DE), W. Nicholson (US),
  J. Pillinger (UK), E. Rabbow (DE),
  P. Rettberg (DE), J. Sprey (UK),
  E. Stackebrandt (DE),
  K. Venkateswaren (US)

- Seeds
  This experiment is testing the plant seed as a terrestrial model for a panspermia vehicle, i.e., a means of transporting life through the universe and as a source of universal UV screens.

  **Science Team:**
  D. Tepfer (DE), L. Sydney (FR),
  S. Hoffmann (DK), P. Ducrot (FR),
  F. Corbineau (FR), C. Wood (UK)

**EVC**

The Earth Viewing Camera (EVC) payload is a fixed-pointed Earth-observing camera. The main goal of the system is to capture color images of the Earth's surface, to be used as a tool to increase general public awareness of the station and promote the use of the station to the potential user community for observation purposes.

**Science Team:**
ESA Erasmus Center (ESA, NL)

## FIPEX

FIPEX is the Flux (Phi) Probe Experiment. It is important to build up a picture of the varying atmospheric conditions in low Earth orbit where orbiting spacecraft are still affected by atmospheric drag. The density of the atmosphere is the major factor affecting drag and this is affected by solar radiation and the Earth's magnetic and gravitational fields. The flux of atomic oxygen is important as it shows different interactions with spacecraft surfaces, e.g., surface erosion. The FIPEX micro-sensor system is being used to measure the atomic oxygen flux as well as the oxygen molecules in the surrounding area of the International Space Station.

**Science Team:**
S. Fasoulas (DE)

## MEDET

The aims of the Materials Exposure and Degradation ExperimenT (MEDET) are: to evaluate the effects of open space on materials currently being considered for utilization on spacecraft in low Earth orbit; to verify the validity of data from the space simulation currently used for materials evaluation; and to monitor solid particles impacting spacecraft in low Earth orbit.

**Science Team:**
V. Inguimbert (FR), A. Tighe – ESA

## PLEGPAY

The scientific objective of PLEGPAY (PLasma Electron Gun PAYload) is the study of the interactions between spacecraft and the space environment in low Earth orbit, with reference to electrostatic charging and discharging. Understanding these mechanisms is very important as uncontrollable discharge events can adversely affect the functioning of spacecraft electronic systems.

**Science Team:**
G. Noci – Laben-Proel (IT)

## Tribolab

This series of experiments covers research in tribology, i.e., the science of friction and lubrication thereof. This is of major importance for spacecraft systems. The Tribolab experiments cover both experiments in liquid and solid lubrication, such as the evaluation of fluid losses from surfaces and the evaluation of wear of polymer and metallic cages in weightlessness.

**Science Team:**
R. Fernandez – INTA (ES)

## EXPOSE-R

The EXPOSE-R facility is a European external facility that was transported to the station on Progress flight 31P for attachment to the outside of the Russian Zvezda service module. It houses a number of experiments covering the areas of photochemistry, photobiology and astrobiology, requiring exposure to the open space environment.

The experiment package is as follows:

**Amino**

The main objective of the Amino experiment is to determine to what extent biologically active molecules (amino acids and peptides) are converted into a mixture of so-called L- and D molecules when exposed to UV-C radiation. (Organic material is principally made up of L-molecules on Earth). The experiment will also determine to what degree the samples are protected by the porous material in which they are accommodated. Another experiment objective is to test whether photosensitive amino acids can use the energy from ultraviolet light from the sun to chain together under space conditions.

**Science Team:**
H. Cottin (FR)

**Endo**

This experiment will assess the impact of increased UV-B and UV-C radiation, due to ozone depletion, on algae and cyanobacteria from Antarctic sites under the ozone hole. It will also determine the probability for endolithic microbial communities, i.e., microbes embedded in rock surfaces, to survive in regions where exposed communities become extinct. The findings will contribute to our understanding of the potential for such communities to have survived UV-exposure in past times on Mars.

**Science Team:**

C.S. Cockell (UK), H.G.M. Edwards (UK)

**Organic**

The goal of the Organic experiment which concerns the evolution of organic matter in space is to study the effects of UV radiation, low pressure, and heavy ion bombardment on organic molecules of interest in astrophysics and astrobiology. This includes polycyclic aromatic hydrocarbons, fullerenes, kerogens of different origin, and complex mixtures.

**Science Team:**

P. Ehrenfreund (NL), Z. Peeters (NL),
B. Foing (ESA, NL), M. Breitfellner (ESA, NL),
F. Robert (FR), E. Jessberger (DE),
W. Schmidt (DE), M. Mumma (US)

**Osmo**

This experiment aims to understand the response of microbes to the vacuum of space and to solar radiation. It will especially focus on bacteria that survive in environments of high osmotic pressure, in this case two bacteria (Synechococcus and Haloarcula-G) that survive in salt-rich environments. It will asses whether these salt-rich environments, as well as the high intracellular potassium concentration of the micro-organisms, play a role in protecting their DNA from drying out in space.

**Science Team:**

R. Mancinelli (US)

**Photo**

This experiment is studying the effect of exposure of bacterial spores and samples of their DNA to solar UV radiation. The objective is to assess the quantity and chemistry of chemical products produced. The samples will be completely exposed, or protected by artificial meteorite materials, clays, and salt crystals.

**Science Team:**

J. Cadet (FR), T. Douki (FR), J.L. Ravanat (FR), S. Sauvaigo (FR)

**PUR**

The Phage and Uracil Response (PUR) experiment is studying the effect of solar UV radiation on a type of virus (Phage T7) and an RNA compound (uracil) to determine their effectiveness as biological dosimeters for measuring UV dose in the space environment.

**Science Team:**

G. Rontó (HU), A. Fekete (HU), P. Gróf (HU)

**Spores**

This experiment will assess how meteorite material acts as a protection for bacterial (*Bacillus subtilis*), fungal (*Trichoderma koningii*) and ferny (*Athyrium filix-femina*, *Dryopteris filix-mas*) spores against space conditions, i.e., UV, vacuum and ionizing radiation.

**Science Team:**

G. Horneck (DE), B. Hock (DE), F. Wänke (DE),
P. Rettberg (DE), D.P. Häder (DE),
G. Reitz (D), T. Dachev (BG), D. Mishev (BG)

**Subtil**

This experiment will determine the extent of mutation of spores and plasmid DNA of the model bacteria Bacillus subtilis induced by exposure to space vacuum and solar UV radiation. Plasmids are DNA segments capable of reproducing themselves independently of chromosomes. The experiment also will study the molecular differentiation in mutations brought about by principal exposure to space vacuum and mutations brought about by just UV exposure. The experiment will use two different strains of the bacteria, one of which is deficient in cellular repair.

**Science Team:**

N. Munkata (JPN), K. Hieda (JPN)

## IBMP Experiments

These experiments from the Institute for Biomedical Problems in Moscow are looking into the effect of exposing a diverse collection of terrestrial organisms in a resting stage of their life cycle to space conditions. Included are bacterial spores, fungal spores, plant seeds and eggs of lower crustacea.

**Science Team:**

V. Sychev (RU), N. Novikova (RU),
S. Poddubko (RU), M. Levenskikh (RU),
T. Agaptseva (RU)

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# Japan Aerospace Exploration Agency Science Operations

## JAXA Kibo Utilization

During Expedition 19/20, the Japan Aerospace Exploration Agency (JAXA) will start external experiment operations outside Kibo, in addition to conducting science research and educational programs on board Kibo.

Kibo's external experiment platform, the Exposed Facility (EF), will be delivered to the International Space Station on the STS-127 mission, along with Kibo's external logistics pallet, the Experiment Logistics Module-Exposed Section (ELM-ES) and two external experiments, SEDA-AP and MAXI.

JAXA's H-II Transfer Vehicle (HTV), the "Technical Demonstration Vehicle," is targeted to be launched to the station in September 2009. The HTV will deliver SMILES, another external experiment to be installed and operated on the EF, as well as science materials, supplies, and spare items.

Three external experiments, SEDA-AP, MAXI, and SMILES, will eventually be conducted on the EF.

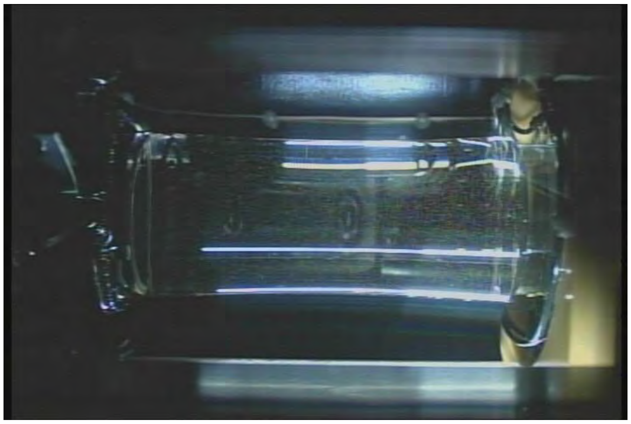
The following are Kibo utilization programs planned for Expedition 19/20.

| Category | Experiment Program |
|---|---|
| Material Science | • Chaos, Turbulence and its Transition Process in Marangoni Convection<br>• Spatio-temporal Flow Structure in Marangoni Convection<br>• Facet (Investigation on Mechanism of Faceted Cellular Array Growth) |
| Life Science | • Space Seed (Life cycle of higher plants under microgravity conditions)<br>• Rad Silk (Integrated assessment of long-term cosmic radiation through biological responses of the silkworm, *Bombyx mori*, in space)<br>• Microbe-I (Microbial dynamics in the International Space Station (Part1)) |

| Category | Experiment Program |
|---|---|
| Applied Research | • JAXA PCG (High-Quality Protein Crystal Growth Experiment) |
| Astrophysics/Earth Observation | • MAXI (Monitor of All-sky X-ray Image)<br>• SMILES (Superconducting Submillimeter-Wave Limb-Emission Sounder)<br>• SEDA-AP (Space Environment Data Acquisition equipment--Attached Payload) |
| Human Space Flight Technology Development | • JAXA Holter (Digital Holter ECG (Electrocardiograph))<br>• Area PADLES (Passive Dosimeter for Life science Experiments in Space) |
| JAXA EPO | • ISS Moon Score<br>• Dewey's Forest |

### Material Science Experiments

**Chaos, Turbulence and its Transition Process in Marangoni Convection** investigates the surface-tension-driven flow that occurs in a liquid bridge. This program was performed in Expedition 17/18 and during Expedition 19/20 further experiments will be performed.



Within a silicone oil liquid bridge formed into a pair of disks, convection is induced by imposing a temperature difference between the disks. The flow and temperature fields in each stage (e.g., steady, oscillatory, and chaotic flow) are observed using several visualization techniques to determine the transition process. The experiment data and images are downlinked in real time and also recorded for detailed analysis. The experiment uses the Fluid Physics Experiment Facility (FPEF) in the RYUTAI rack.

**Principal Investigator:**
Hiroshi Kawamura, Tokyo University of Science

**Spatio-temporal Flow Structure in Marangoni Convection** is another Marangoni experiment that will be performed on board Kibo. The operational method is almost the same as that of the Chaos, Turbulence and its Transition Process in Marangoni Convection. The flow phenomenon is to be investigated by using the pulsed ultrasonic velocity profiler to obtain the spatio-temporal velocity field inside the fluid column, so as to investigate and clarify the flow transition scheme from laminar to turbulence through chaos. The experiment cell of this experiment will be delivered to the ISS via the HTV.

**Principal Investigator:**
Yasushi Takeda, Hokkaido University

**Facet** (Investigation on Mechanism of Faceted Cellular Array Growth) will investigate phenomena at the solid-liquid interface for facet-like crystallization that are considered to be strongly influenced by the temperature and concentration distributions in the liquid phase. The in-situ observation of both concentration and temperature diffusion fields with a two-wavelength interferometer will be performed for facet-like crystallization using transparent organic materials under microgravity conditions, a convection-free environment. The Facet Cell 1 will be installed in the Solution Crystallization Observation Facility (SCOF) in the RYUTAI rack. After completing the first set of experiments with Facet Cell 1, a crew member will change the direction of the facet cell so that more experiments using Facet Cell 2 can be performed.

**Principal Investigator:**
Yuko Inatomi, JAXA

## Life Science Experiments

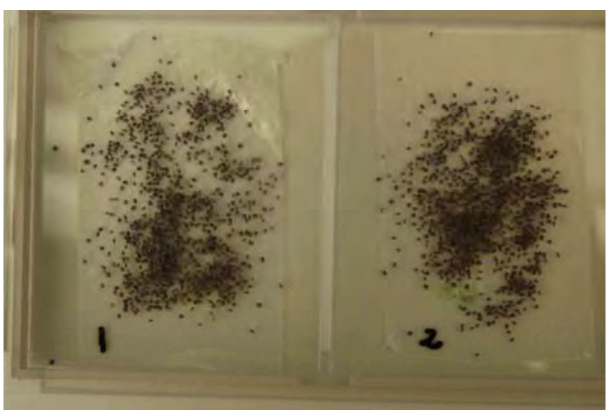
**Space Seed** (Life cycle of higher plants under microgravity conditions) will investigate the role of gravity in regulating the developmental processes of higher plants, using seeds of Arabidopsis thaliana, also known as arabidopsis or thale cress.

***Plant Experiment Unit (PEU)***

The seeds will be planted in the plant experiment sample chambers in the Plant Experiment Unit (PEU) before launch. On orbit, the plants in the eight PEUs will be incubated in the Cell Biology Experiment Facility (CBEF) in the SAIBO rack and will be observed using the PEU CCD camera. After 30 days of incubation, half of the germinated samples (stems, leaves, and roots) will be harvested, fixed, and stored in the Minus Eighty degrees Laboratory Freezer for the ISS (MELFI) at 2°C (35.6°F) and -95°C (-139°F). A quarter of the other half will be harvested after an additional 30 days of incubation then fixed and refrigerated in the MELFI. The rest of the samples also will be refrigerated. All the stored samples will be returned to the ground for analysis.

**Principal Investigator:**
Seiichiro Kamisaka, Toyama University

**Rad Silk** (Integrated assessment of long-term cosmic radiation through biological responses of the silkworm, Bombyx mori, in space) will examine the effects of space radiation and microgravity on silkworm eggs. The silkworm egg is assumed to have a highly sensitive stage for radiation exposure after diapause, since white spots are observed on silkworm caterpillars when exposed to radiation during their egg stages. The eggs will be placed in egg cases. After the launch at 4°C (39.2°F), the eggs in the egg cases will be kept cool in the MELFI at 2°C (35.6°F) for diapause. Before returning to the ground, the eggs will be incubated at 20°C (68°F) for eight days using the CBEF, then stored in the MELFI at 2°C (35.6°F). Some eggs will be frozen at -95°C (-139°F). As the control sample, one egg case will remain at 2°C (35.6°F) without incubation. On the ground, the returned eggs will be germinated, and their radiation effects will be analyzed with mutation assay, genetic assay, and biochemical assays.



***Left: No radiation exposure during the egg stage***
***Right: Exposed to radiation during the egg stage***

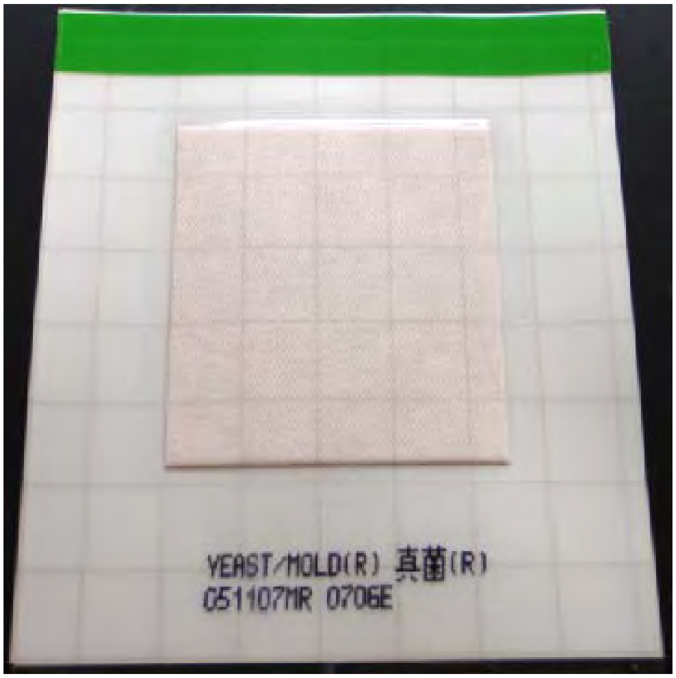
**Principal Investigator:**
Toshiharu Furusawa, Kyoto Institute of Technology University

**Microbe-I** [Microbial dynamics in the International Space Station (Part1)] will monitor microbes, especially fungi and bacteria, in Kibo.

The environment on board the ISS is controlled to be comfortable for the crew and for saprophytic microorganisms. Therefore, it is possible that the crew and equipment are exposed to a high concentration of microbes, especially fungal spores, in the enclosed environment. Thus, it is essential to investigate the microbial biota present in the space station in order to control microbial infection, allergies, and disaster.

This experiment includes sampling with the use of a microbial detection sheet for yeast and mold, and a swab and sampling tube in the three specific surfaces in Kibo for culture, direct microscopy, and molecular biological analysis.

**Principal Investigator:**
Koichi Makimura, Teikyo University




***Microbial detection sheet for yeast and mold, and grown mold on fabric sheet***

***Swab and sampling tube***

## Applied Research

**JAXA PCG** (High-Quality Protein Crystal Growth Experiment) seeks to grow crystals of biological macromolecules by the counter-diffusion technique. The main scientific objective of the JAXA PCG experiment is to produce fine-quality protein crystals in a microgravity environment.

The crystals will be grown in the JAXA PCG Canister using the Protein Crystallization Research Facility (PCRF) in the RYUTAI rack.

The space-grown crystals will be applied to structural biology and pharmaceutical activities.

***JAXA PCG Canister and PCRF***


***JAXA PCG Canister in a canister bag***

**Science Team:**
T. Kobayashi, M. Sato, and S. Sano, JAXA

## Astrophysics/Earth Observations

**MAXI** (Monitor of All-sky X-ray Image) is an external observatory that will be operated on the Exposed Facility (EF). MAXI will monitor the X-ray variability for more than 1,000 X-ray sources covering the entire sky. MAXI consists of two types of highly sensitive X-ray slit cameras, the Gas Slit Camera (GSC) and the Solid-state Slit Camera (SSC). The GSC uses a gas proportional counter for X-ray detection, and the SSC uses peltier-cooled CCDs for X-ray detection. MAXI is equipped with 12 GSCs and two SSCs.

The discoveries of X-ray novae and gamma-ray bursts with MAXI will be distributed worldwide via the Internet, so that the astronomical observatories may conduct follow-up and detailed observations by telescopes or astronomical satellites.

***MAXI***

**Principal Investigator:**
Masaru Matsuoka, JAXA

**SMILES** (Superconduction Submillimeter-wave Limb-Emission Sounder) is an external observatory that will be operated on the EF. SMILES aims at global mapping of stratospheric trace gases, using the most sensitive sub millimeter receiver. A Superconductor Insulator Superconductor (SIS) mixer in a dedicated cryostat with a mechanical cooler achieved SMILES's super-high sensitivity. SMILES will observe ozone-depletion-related molecules such as ClO, HCl, HO2, HNO3, BrO, and O3 in the frequency bands of 624.32 to 626.32GHz and 649.12 to 650.32GHz. A scanning antenna will cover tangent altitudes from 10 to 60km every 53 seconds, while tracing the latitudes from 38°S to 65°N along its orbit.

Due to its global coverage capability, SMILES can observe the low- and mid-latitudinal areas, as well as the Arctic peripheral region.

SMILES data will enable us to investigate chlorine and bromine chemistry, and will provide a database for ozone variations in time and position around the upper troposphere and lower stratosphere.

***SMILES***

**Principal Investigator:**
Masato Shiotani, Kyoto University

**SEDA-AP** (Space Environment Data Acquisition equipment – Attached Payload) is an external instrument to be operated on the EF. SEDA-AP collects space environment data. It consists of common bus equipment, an extendible mast that extends the neutron monitor sensor into space, and seven measurement units that measure space environment data. The measurement units are (1) Neutron Monitor (NM), (2) Heavy Ion Telescope (HIT), (3) Plasma Monitor (PLAM), (4) Standard Dose Monitor (SDOM), (5) Atomic Oxygen Monitor (AOM), (6) Electronic Device Evaluation Equipment (EDEE), and (7) Micro-Particles Capture (MPAC) and Space Environment Exposure Device (SEED).

***SEDA-AP***

**Principal Investigator:**
Tateo Goka, JAXA

## Human Space Flight Technology Development

**JAXA Holter** verifies JAXA's Digital Holter ECG (Electrocardiograph), which was developed for monitoring the circadian (24h) cardiovascular and autonomic functions of astronauts in orbit. The ultimate goal is to understand the effects of microgravity and long-duration spaceflight on the cardiovascular and autonomic systems of astronauts who stay in orbit for long durations. This research also evaluates changes in skin condition before and after attaching the ECG electrodes for crew health and safety.

The ECG measurements will be conducted four times at different measuring points (once preflight, twice in-flight, and once post-flight). The ECG electrodes will be attached to the chest wall of a crew member to monitor heart rate and arrhythmia (irregular heartbeat). After the 24h ECG measurement, the crew member's chest will be videoed by a High-Definition Television (HDTV) camera to record visual changes in the skin condition where the ECG electrodes were attached.

**Principal Investigator:**
Chiaki Mukai, JAXA

**Area PADLES** (Passive Dosimeter for Life Science Experiments in Space) surveys the space radiation environment inside Kibo using PADLES analysis system and passive and integrating dosimeter developed by JAXA for measuring absorbed dose, LET distributions and dose equivalents. Ultimate goals of this program are to support risk assessment and dose management for Japanese astronauts, and to update radiation assessment models for the human spaceflight in the next generation. There are 12 Area PADLES dosimeters installed in Kibo's Pressurized Module (PM) and they are replaced each space station increment. After the STS-128 mission (17A), the numbers of Area PADLES in Kibo will be increased to 17; some of them will be installed in Kibo's Experiment Logistics Module-Pressurized Section (ELM-PS) as well as in the PM. This is the series experiments in succession from Expedition17.

Additionally, another type of PADLES, called Experiment PADLES (Exp PADLES), will be installed in the ELM-PS during the Expedition 19/20 to investigate the directional distributions of the fluxes and doses in the ELM-PS. This study is needed to determine the storage location and directions where the onboard equipment (or experiments) are less affected by the radiation environment inside the ISS.

**Principal Investigator:**
A. Nagamatsu, K. Murakami, JAXA


*(a) Area PADLES dosimeter*


*(b) Exp PADLES dosimeter (mockup)*

## JAXA Education Payload Observations (JAXA EPO)

The JAXA Educational Payload Observation (EPO) focuses on educational and cultural activities, and artistic experiments. The following programs are planned for Expedition 19/20.

**ISS Moon Score** is an artistic experiment aimed at composing music using photos of the moon. The Expedition 19/20 crew members will take 80 to 100 photos of the moon, using a digital camera from Kibo's windows. The photos will be downlinked to the ground for musical score composition.

**Dewey's Forest** is a cultural experiment that demonstrates how gravity controls the laws of nature and influences our way of thinking. This experiment also will seek to rediscover the relationship between humans and plants, and the age-old history of our gardens. The Expedition 19/20 crew members will prepare this experiment.

# Digital NASA Television

NASA Television can be seen in the continental United States on AMC-6, at 72 degrees west longitude, Transponder 17C, 4040 MHz, vertical polarization, FEC 3/4, Data Rate 36.860 MHz, Symbol 26.665 Ms, Transmission DVB. If you live in Alaska or Hawaii, NASA TV can now be seen on AMC-7, at 137 degrees west longitude, Transponder 18C, at 4060 MHz, vertical polarization, FEC 3/4, Data Rate 36.860 MHz, Symbol 26.665 Ms, Transmission DVB.

Digital NASA TV system provides higher quality images and better use of satellite bandwidth, meaning multiple channels from multiple NASA program sources at the same time.

Digital NASA TV has four digital channels:

1. NASA Public Service ("Free to Air"), featuring documentaries, archival programming, and coverage of NASA missions and events.
2. NASA Education Services ("Free to Air/Addressable"), dedicated to providing educational programming to schools, educational institutions and museums.
3. NASA Media Services ("Addressable"), for broadcast news organizations.
4. NASA Mission Operations (Internal Only).

Note: Digital NASA TV channels may not always have programming on every channel simultaneously.

## Internet Information

Information is available through several sources on the Internet. The primary source for mission information is the NASA Human Space Flight Web, part of the World Wide Web. This site contains information on the crew and its mission and will be updated regularly with status reports, photos and video clips throughout the flight. The NASA Shuttle Web's address is:

**http://spaceflight.nasa.gov**

General information on NASA and its programs is available through the NASA Home Page and the NASA Public Affairs Home Page:

**http://www.nasa.gov**

or

**http://www.nasa.gov/newsinfo/index.html**

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